SECTION 16417

ELECTRICAL WORK, POWER AND CONTROL FOR SMALL CIVIL PROJECTS
12/2000

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(1995) Code for Electricity Metering
ANSI C12.4	(1984; R 1996) Mechanical Demand Registers
ANSI C12.10	(1987) Electromechanical Watthour Meters
ANSI C12.11	(1987; R 1993) Instrument Transformers for Revenue Metering, 10 kV BIL Through 350 kV BIL (0.6 kV NSV Through 69 kV NSV)
ANSI C37.16	(1988; C37.16a; R 1995) Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors - Preferred Ratings, Related Requirements, and Application Recommendations
ANSI C39.1	(1981; R 1992) Requirements for Electrical Analog Indicating Instruments
ANSI C57.12.10	(1987) Safety Requirements for Transformers 230 kV and Below 833/958 Through 8333/10417 kVA, Single-Phase, and 750/862 Through 60 000/80 000/100 000 kVA, Three-Phase Without Load Tap Charging; and 3750/4687 Through 60 000/80 000/100 000 kVA With Load Tap Charging
ANSI C57.12.13	(1982) Conformance Requirements for Liquid-Filled Transformers Used in Unit Installations, Including Unit Substations
ANSI C57.12.27	(1982) Conformance Requirements for Liquid-Filled Distribution Transformers Used in Pad-Mounted Installations, Including Unit Substations
ANSI C57.12.50	(1981; R 1989) Ventilated Dry-type Distribution Transformers 1 to 500 kVA, Single-Phase; and 15 to 500 kVA, Three-Phase with High-Voltage 601 to 34 500 Volts, Low-Voltage 120 to 600 Volts

ANSI C57.12.51	(1981; R 1989) Ventilated Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase, with High-Voltage 601 to 34 500 Volts, Low-Voltage 208Y/120 to 4160 Volts
ANSI C57.12.52	(1981; R 1989) Sealed Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase with High-Voltage 601 to 34 500 Volts, Low-Voltage 208Y/120 to 4160 Volts
ANSI C57.12.70	(1978; R 1993) Terminal Markings and Connections for Distribution and Power Transformers
ANSI C80.5	(1995) Rigid Aluminum Conduit
ANSI C82.1	(1985; C82.1a; C82.1b; C82.1c; C82.1d; C82.1e; R 1992) Specifications for Fluorescent Lamp Ballasts
ANSI C82.4	(1992) Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type)
ANSI C135.30	(1988) Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 1	(1995) Hard-Drawn Copper Wire
ASTM B 8	(1995) Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM A 366	(2000) Standard Specification for Commercial Steel (CS) Sheet, Carbon (0.15 Maximum Percent) Cold-Rolled
ASTM D 709	(1992; R 1997) Laminated Thermosetting Materials
ASTM D 4059	(1996) Analysis of Polychlorinated Biphenyls in Insulating Liquids by Gas Chromatography

CODE OF FEDERAL REGULATIONS (CFR)

47 CFR 18	Industrial, Scientific, and Medical Equipment

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA, formerly IPCEA)

ICEA Standards	Insulated Cable Engineers Association Standards

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(1997) National Electrical Safety Code
IEEE ANSI/IEEE C37.13	(1990; R 1995) Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE ANSI/IEEE C37.20.1	(1993) Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear
IEEE ANSI/IEEE C57.12.00	(1993) IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE ANSI/IEEE C57.12.80	(1978; R 1992) Terminology for Power and Distribution Transformers
IEEE ANSI/IEEE C57.12.90	(1993) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers
IEEE ANSI/IEEE C57.13	(1993) Instrument Transformers
IEEE ANSI/IEEE C57.98	(1993) Guide for Transformer Impulse Tests
IEEE ANSI/IEEE C57.100	(1986; R 1992) Test Procedure for Thermal Evaluation of Oil-Immersed Distribution Transformers
IEEE C62.11	(1999) IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits
IEEE C62.41	(1991; R 1995) Surge Voltages in Low-Voltage AC Power Circuits
IEEE C62.45	IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits
IEEE Std 80	(1986; R1991) IEEE Guide for Safety in AC Substation Grounding
IEEE Std 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1)
IEEE Std 242	(1986; R 1991) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
IEEE Std 383	(1974; R 1992) IEEE Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations Ref Title
IEEE Std 399	(1990) Recommended Practice for Industrial and Commercial Power Systems Analysis

IEEE Std 837	(1989; R1996 IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(1991) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 1	(1993) Molded Case Circuit Breakers and Molded Case Switches
NEMA BU 1	(1994) Busways
NEMA FU 1	(1986) Low Voltage Cartridge Fuses
NEMA ICS 1	(1993) Industrial Control and Systems
NEMA ICS 2	(1993) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated Not More Than 2,000 Volts AC or 750 Volts DC
NEMA ICS 3	(1993) Industrial Control and Systems Factory Built Assemblies
NEMA ICS 6	(1993) Industrial Control and Systems Enclosures
NEMA LE 4	(1987) Recessed Luminaires, Ceiling Compatibility
NEMA MG 1	(1993; Rev 1; Rev 2; Rev 3) Motors and Generators
NEMA MG 10	(1994) Energy Management Guide for Selection and Use of Polyphase Motors
NEMA OS 1	(1989) Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
NEMA OS 2	(1986; Errata Aug 1986; R 1991) Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports
NEMA PB 1	(1990) Panelboards
NEMA PB 2	(1995) Deadfront Distribution Switchboards
NEMA PE 5	(1985; R 1991) Utility Type Battery Chargers
NEMA RN 1	(1989) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA SG 3	(1995) Power Switching Equipment

NEMA ST 20	(1992) Dry-Type Transformers for General Applications
NEMA TC 2	(1990) Electrical Polyvinyl Chloride (PVC) Tubing (EPT) and Conduit (EPC-40 and EPC-80)
NEMA TC 13	(1993) Electrical Nonmetallic Tubing (ENT)
NEMA VE 1	(1996) Metal Cable Tray Systems
NEMA WC 8	(1988; R 1996) Ethylene Propylene Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S 68 516)
NEMA WD 1	(1983; R 1989) General Requirements for Wiring Devices
NEMA WD 6	(1988) Wiring Devices - Dimensional Requirements

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1999) National Electrical Code
NFPA 101	(2000) Life Safety Code

UNDERWRITERS LABORATORIES (UL)

UL 1	(1993; Rev thru Jan 1995) Flexible Metal Conduit
UL 4	(1996) Armored Cable
UL 5	(1996) Surface Metal Raceways and Fittings
UL 6	(1997) Rigid Metal Conduit
UL 20	(1995; Rev thru Jan 1998) General-Use Snap Switches
UL 44	(1997; Rev Aug 1997) Thermoset-Insulated Wires and Cables
UL 50	(1995; Rev thru Oct 1997) Enclosures for Electrical Equipment
UL 67	(1993; Rev thru Nov 1995) Panelboards
UL 83	(1996; Rev Sep 1997) Thermoplastic-Insulated Wires and Cables
UL 94	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 98	(1994; R thru Oct 1995) Enclosed and

	Dead-Front Switches
UL 198B	(1995) Class H Fuses
UL 198C	(1986; Rev thru Feb 1998) High-Interrupting-Capacity Fuses, Current-Limiting Types
UL 198D	(1995) Class K Fuses
UL 198E	(1988; Rev Jul 1988) Class R Fuses
UL 198G	(1988; Rev May 1988) Fuses for Supplementary Overcurrent Protection
UL 198H	(1988; Rev thru Nov 1993) Class T Fuses
UL 198L	(1995; Rev May 1995) D-C Fuses for Industrial Use
UL 360	(1996; Rev thru Oct 1997) Liquid-Tight Flexible Steel Conduit
UL 467	(1993; Rev thru Aug 1996) Grounding and Bonding Equipment
UL 486A	(1997) Wire Connectors and Soldering Lugs for Use with Copper Conductors
UL 486B	(1997; Rev Jun 1997) Wire Connectors for Use with Aluminum Conductors
UL 486C	(1997) Splicing Wire Connectors
UL 486E	(1994; Rev thru Feb 1997) Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
UL 489	(1996; Rev thru Nov 1997) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 498	(1996; Rev thru Nov 1997) Attachment Plugs and Receptacles
UL 506	(1994; Rev Oct 1997) Specialty Transformers
UL 508	(1993; Rev thru Oct 1997) Industrial Control Equipment
UL 510	(1994; Rev thru Nov 1997) Insulating Tape
UL 512	(1993; R Dec 1995) Fuseholders
UL 514A	(1996) Metallic Outlet Boxes
UL 514B	(1997) Fittings for Conduit and Outlet Boxes

UL 514C	(1996) Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 542	(1994; Rev May 1997) Lampholders, Starters, and Starter Holders for Fluorescent Lamps
UL 651	(1995; Rev thru Apr 1997) Schedule 40 and 80 Rigid PVC Conduit
UL 651A	(1995; Rev Sep 1996) Type EB and A Rigid PVC Conduit and HDPE Conduit
UL 674	(1994; Rev thru Feb 1997) Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations
UL 698	(1995; Rev thru Dec 1996) Industrial Control Equipment for Use in Hazardous (Classified) Locations
UL 719	(1996) Nonmetallic-Sheathed Cables
UL 797	(1993; Rev thru Mar 1997) Electrical Metallic Tubing
UL 817	(1994; Rev thru Aug 1997) Cord Sets and Power-Supply Cords
UL 844	(1995; Rev thru Aug 1997) Electric Lighting Fixtures for Use in Hazardous (Classified) Locations
UL 845	(1995; Rev Feb 1996) Motor Control Centers
UL 854	(1996) Service-Entrance Cables
UL 857	(1994; Rev thru Nov 1996) Busways and Associated Fittings
UL 869A	(1993; Rev thru Apr 1996) Reference Standard for Service Equipment
UL 877	(1993; Rev thru May 1997) Circuit Breakers and Circuit-Breaker Enclosures for Use in Hazardous (Classified) Locations
UL 886	(1994; Rev thru Jan 1997) Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations
UL 891	(1994; Rev thru Jan 1995) Dead-Front Switchboards
UL 924	(1995; Rev thru Oct 97) Emergency Lighting and Power Equipment
UL 935	(1995; Rev thru Apr 1997)Fluorescent-Lamp Ballasts

UL 943	(1993; Rev thru Mar 1997)Ground-Fault Circuit-Interrupters
UL 1004	(1994; Rev thru Feb 1997) Electric Motors
UL 1010	(1995; Rev thru Dec 1996)Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations
UL 1022	(1994) Line Isolation Monitors
UL 1029	(1994; Rev thru Sep 1995) High-Intensity-Discharge Lamp Ballasts
UL 1047	(1995; Rev May 1996) Isolated Power Systems Equipment
UL 1236	(1994; Rev thru Dec 1997) Battery Chargers for Charging Engine-Starter Batteries
UL 1242	(1996; Rev Apr 1997) Intermediate Metal Conduit
UL 1277	(1989)Electrical Power and Control Tray Cables with Optional Optical-Fiber Members
UL 1283	(1993) Electromagnetic Interference Filters
UL 1449	(1985; Errata Apr 1986; Rev May 1995) Transient Voltage Surge Suppressors
UL 1564	(1993; Rev Apr 1994) Industrial Battery Chargers
UL 1569	(1995; Rev thru Oct 1997) Metal-Clad Cables
UL 1570	(1995; Rev thru Jun 1997) Fluorescent Lighting Fixtures
UL 1571	(1995; Rev thru Jun 97) Incandescent Lighting Fixtures
UL 1572	(1995; Rev thru Jun 97) High Intensity Discharge Lighting Fixtures
UL 1660	(1994; Rev Jan 1996) Liquid-Tight Flexible Nonmetallic Conduit
UL 1581	(1997) Reference Standard for Electrical Wires, Cables, and Flexible Cords
UL Elec Const Dir	(1997) Electrical Construction Equipment Directory

1.2 GENERAL

1.2.1 Rules

The installation shall conform to the requirements of NFPA 70 and NFPA 101, unless more stringent requirements are indicated or shown.

1.2.2 Coordination

The drawings indicate the extent and the general location and arrangement of equipment, conduit, and wiring. The Contractor shall become familiar with all details of the work and verify all dimensions in the field so that equipment shall be properly located and readily accessible. Equipment and materials shall be located to avoid interference with mechanical or structural features. If any conflicts occur necessitating departures from the drawings, details of and reasons for departures shall be submitted and approved prior to implementing any change.

1.2.3 Special Environments

1.2.3.1 Weatherproof Locations

Wiring, fixtures, and equipment in exterior locations shall conform to NFPA 70 requirements for wet locations.

1.2.3.2 Hazardous Locations

[Wiring in locations indicated shall conform to the NFPA 70 for Class [I] [II] [III], Division [1] [2] hazardous locations. Equipment shall be suitable for [Group [_____]] [operating temperature of [_____] degrees C degrees F].] [Wiring and equipment in locations indicated shall be of the classes, groups, divisions, and suitable for the operating temperature; as indicated.]

1.2.3.3 Ducts, Plenums and Other Air-Handling Spaces

Wiring and equipment in ducts, plenums and other air-handling spaces shall be installed using materials and methods in conformance with NFPA 70unless more stringent requirements are indicated in this specification or on the contract drawings.

1.2.4 Standard Products

Material and equipment shall be standard products of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

1.2.5 Nameplates

1.2.5.1 Identification Nameplates

Major items of electrical equipment and major components shall be permanently marked with an identification name to identify the equipment by type or function and specific unit number[as indicated]. Designation of motors shall coincide with their designation in the motor control center or panel. Unless otherwise specified, identification nameplates shall be made of laminated plastic in accordance with ASTM D 709 with black outer layers and a white core. Edges shall be chamfered. Plates shall be fastened with

black-finished round-head drive screws, except motors, or approved nonadhesive metal fasteners. When the nameplate is to be installed on an irregular-shaped object, the Contractor shall devise an approved support suitable for the application and ensure the proper installation of the supports and nameplates. In all instances, the nameplate shall be installed in a conspicuous location. At the option of the Contractor, the equipment manufacturer's standard embossed nameplate material with black paint-filled letters may be furnished in lieu of laminated plastic. The front of each panelboard, motor control center, switchgear, and switchboard shall have a nameplate to indicate the phase letter, corresponding color and arrangement of the phase conductors. The following equipment, as a minimum, shall be provided with identification nameplates:

Minimum 6.4 mm High Letters	Minimum 3.2 mm High Letters
Panelboards	Control Power Transformers
Starters	Control Devices
Safety Switches	Instrument Transformers
Motor Control Centers	
Transformers	
Equipment Enclosures	
Switchgear	
Switchboards	
Motors	

Minimum 1/4 inch High Letters	Minimum 1/8 inch High Letters
Panelboards	Control Power Transformers
Starters	Control Devices
Safety Switches	Instrument Transformers
Motor Control Centers	
Transformers	
Equipment Enclosures	
Switchgear	
Switchboards	
Motors	

Each panel, section, or unit in motor control centers, switchgear or similar assemblies shall be provided with a nameplate in addition to nameplates listed above, which shall be provided for individual compartments in the respective assembly, including nameplates which identify "future," "spare," and "dedicated" or "equipped spaces."

1.2.5.2 Liquid-Filled Transformer Nameplates

Power transformers shall be provided with Nameplate C information in accordance with IEEE ANSI/IEEE C57.12.00. Nameplates shall indicate percent impedance, voltage, kVA, frequency, number of phases, cooling class, insulation class, temperature rise, the number of gallons and composition of liquid-dielectric, and shall be permanently marked with a statement that the transformer dielectric to be supplied is non-polychlorinated biphenyl. The Contractor shall furnish manufacturer's certification for each transformer that the dielectric is non-PCB classified, with less than 2 ppm PCB content in accordance with paragraph LIQUID DIELECTRICS. Certifications shall be related to serial numbers on transformer nameplates. Transformer dielectric exceeding the [50] [2] ppm PCB content or transformers without certification will be considered as PCB

insulated and will not be accepted.

1.2.6 As-Built Drawings

Following the project completion or turnover, within 30 days the Contractor shall furnish 2 sets of as-built drawings to the Contracting Officer.

1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-01 Data

Fault Current and Protective Device Coordination Study; FIO.

The study shall be submitted along with protective device equipment submittals. No time extensions or similar contract modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed shall be based on recommendations of this study, The Government shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study.

Manufacturer's Catalog; FIO.

Data shall consist of catalog cuts, brochures, circulars, specifications, product data, and printed information in sufficient detail and scope to verify compliance with the requirements of the contract documents.

Material, Equipment[, and Lighting Fixtures] Lists; FIO.

Combination Meter and Current Transformer Cabinet; FIO.

Float Switches; FIO..

A complete itemized listing of equipment and materials proposed for incorporation into the work. Each entry shall include an item number, the quantity of items proposed, and the name of the manufacturer of each item.

Grounding and Bonding Connections; FIO

Complete listing of equipment and materials, including statements of compliance with applicable references. Each entry shall include an item number, the quantity of items proposed, and name of the manufacturer.

Installation Procedures; FIO.

Installation procedures for [rotating equipment,][transformers,][switchgear,][battery systems,][voltage regulators,][grounding resistors][_____]. Procedures shall include diagrams, instructions, and precautions required to install, adjust, calibrate, and test devices and equipment.

SD-04 Drawings; FIO

Detail drawings shall consist of equipment drawings, illustrations, schedules, instructions, diagrams, and other information necessary to define the installation. Detail drawings shall show the rating of items and systems and how the components of an item and system are assembled, function together, and how they will be installed on the project. Data and drawings for component parts of an item or system shall be coordinated and submitted as a unit. Data and drawings shall be coordinated and included in a single submission. Multiple submissions for the same equipment or system are not acceptable except where prior approval has been obtained from the Contracting Officer. In such cases, a list of data to be submitted later shall be included with the first submission. Detail drawings shall show physical arrangement, construction details, connections, finishes, materials used in fabrication, provisions for conduit or busway entrance, access requirements for installation and maintenance, physical size, electrical characteristics, foundation and support details, and equipment weight. Drawings shall be drawn to scale and/or dimensioned. Optional items shall be clearly identified as included or excluded. Detail drawings shall, as a minimum, include:

Valve Operators and Controls.

Combination Starters

Remote Control Stations

Transformers.

Switchgear.

Battery system including calculations for the battery and charger.

Voltage regulators.

Grounding resistors.

Motors and rotating machinery.

Structural drawings showing the structural or physical features of major equipment items, components, assemblies, and structures, including foundations or other types of supports for equipment and conductors. These drawings shall include accurately scaled or dimensioned outline and arrangement or layout drawings to show the physical size of equipment and components and the relative arrangement and physical connection of related components. Weights of equipment, components and assemblies shall be provided when required to verify the adequacy of design and proposed construction of foundations or other types of supports. Dynamic forces shall be stated for switching devices when such forces must be considered in the design of support structures. The appropriate detail drawings shall show the provisions for leveling, anchoring, and connecting all items during installation, and shall include any recommendations made by the manufacturer.

Electrical drawings shall include single-line and three-line diagrams, and schematics or elementary diagrams of each electrical system; internal wiring and field connection diagrams of each electrical device when published by the manufacturer; wiring diagrams of cabinets, panels, units, or separate mountings; interconnection diagrams that show the wiring

between separate components of assemblies; field connection diagrams that show the termination of wiring routed between separate items of equipment; internal wiring diagrams of equipment showing wiring as actually provided for this project. Field wiring connections shall be clearly identified.

If departures from the contract drawings are deemed necessary by the Contractor, complete details of such departures, including changes in related portions of the project and the reasons why, shall be submitted with the detail drawings. Approved departures shall be made at no additional cost to the Government.

As-Built Drawings; FIO.

The as-built drawings shall be a record of the construction as installed. The drawings shall include all the information shown on the contract drawings, deviations, modifications, and changes from the contract drawings, however minor. The as-built drawings shall be kept at the job site and updated daily. The as-built drawings shall be a full-sized set of prints marked to reflect all deviations, changes, and modifications. The as-built drawings shall be complete and show the location, size, dimensions, part identification, and other information. Additional sheets may be added. The as-built drawings shall be jointly inspected for accuracy and completeness by the Contractor's quality control representative and by the Contracting Officer prior to the submission of each monthly pay estimate. Upon completion of the work, the Contractor shall submit three full sized sets of the marked prints to the Contracting Officer for approval. If upon review, the as-built drawings are found to contain errors and/or omissions, they will be returned to the Contractor for correction. The Contractor shall correct and return the as-built drawings to the Contracting Officer for approval within ten calendar days from the time the drawings are returned to the Contractor.

SD-08 Statements

Onsite Test; FIO.

A detailed description of the Contractor's proposed procedures for on-site tests.

SD-09 Reports

Factory Test Reports, Pump Motors; FIO.

Six copies of the information described below in 216 x 280 mm 8 1/2 x 11 inch binders having a minimum of 5 rings from which material may readily be removed and replaced, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs.

a. A list of equipment used, with calibration certifications.

b. A copy of measurements taken.

c. The dates of testing.

d. The equipment and values to be verified.

e. The conditions specified for the test.

f. The test results, signed and dated.

g. A description of adjustments made.

Field Test Plan; FIO.

A detailed description of the Contractor's proposed procedures for onsite test submitted 30 days prior to testing the installed system. No field test will be performed until the test plan is approved. The test plan shall consist of complete field test procedures including tests to be performed, test equipment required, and tolerance limits.

Field Test Reports; FIO.

Six copies of the information described below in 216 x 280 mm 8 1/2 x 11 inch binders having a minimum of 5 rings from which material may readily be removed and replaced, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs.

a. A list of equipment used, with calibration certifications.

b. A copy of measurements taken.

c. The dates of testing.

d. The equipment and values to be verified.

e. The conditions specified for the test.

f. The test results, signed and dated.

g. A description of adjustments made.

h. Final position of controls and device settings.

1.4 WORKMANSHIP

Materials and equipment shall be installed in accordance with NFPA 70, recommendations of the manufacturer, and as shown.

PART 2 PRODUCTS

Products shall conform to the respective publications and other requirements specified below. Materials and equipment not listed below shall be as specified elsewhere in this section. Items of the same classification shall be identical, including equipment, assemblies, parts, and components.

2.1 BUSWAYS

UL 857. Busses shall be [copper] [or] [aluminum]. Enclosures shall be [steel] [aluminum]. Short-circuit ratings, except as indicated, shall be in accordance with NEMA BU 1.

2.1.1 Feeder Busways

Feeder busways shall be [ventilated, except that vertical busways within 1.8 meters 6 feet of floors shall be unventilated] [unventilated] low-impedance busway.

2.1.2 Plug-In Busways

Plug-in busways shall be unventilated. [A hook stick of suitable length shall be provided for operating plug-in units from the floor.] [Plug-in units shall be of the circuit-breaker type.] [Plug-in units shall be of the handle-operated switch type equipped with high-interrupting-capacity current-limiting fuses.]

2.2 CABLES AND WIRES

Conductors No. 8 AWG and larger diameter shall be stranded. Conductors No. 10 AWG and smaller diameter shall be solid, except that conductors for remote control, alarm, and signal circuits, classes 1, 2, and 3, shall be stranded unless specifically indicated otherwise. Conductor sizes and ampacities shown are based on copper, unless indicated otherwise. All conductors shall be copper.

2.2.1 Equipment Manufacturer Requirements

When manufacturer's equipment requires copper conductors at the terminations or requires copper conductors to be provided between components of equipment, provide copper conductors or splices, splice boxes, and other work required to meet manufacturer's requirements.

2.2.2 Aluminum Conductors

Aluminum conductors shall not be used.

2.2.3 Building Wire

Unless indicated otherwise, or required by NFPA 70, power and lighting wires shall be 600-volt, dual rated Type THWN-2/THHN-2, conforming to UL 83. Conductors shall be solid for sizes No. 8 AWG and smaller; stranded for No. 6 AWG and larger, and for equipment connections. Where lighting fixtures require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.2.4 Bonding Conductors

ASTM B 1, solid bare copper wire for sizes No. 8 AWG and smaller diameter; ASTM B 8, Class B, stranded bare copper wire for sizes No. 6 AWG and larger diameter.

2.2.5 Power and Control Tray Cable

a. Conductors: Tin-coated copper per ASTM B 8.

b. Insulation: Heat, moisture, flame and chemical resistant ethylene-propylene rubber. Insulated conductors UL rated VW-1.

c. Color Coding: Per ICEA Standards, Method 1, E-2. For sizes #8 and larger, surface printing of numbers per ICEA Standards, Method 4..

d. Grounding Conductor: Where indicated, bare standed copper per ASTM B 8, Class B and Table 250-95 of the National Electrical Code.

e. Assembly: Conductors cabled in accordance with UL 1277 using fillers as necessary, with a cable tape overall.

f. Jacket: Black, flame-retardant polyvinyl chloride per UL 1581. UL 1277.

g. Compliance: UL listed as Tray Cable, suitable for wet or dry locations with conductor operating temperatures to 90C, emergency overload rating to 130C, and short circuit rating to 250C. Pass vertical tray flame test requirements of IEEE Std 383 and UL 1277. Sunlight resistant, oil resistant, and for use at elevated temperatures.

2.2.6 Instrumentation Tray Cable

a. Conductors: Bare soft annealed copper, Class B, 7-strand concentric per ASTM B 8.

b. Insulation: Flame-retardant polyvinyl chloride.

c. Conductor Identification: Black and white in pairs. White conductor numerically printed for group identification, in multiple pairs cables.

d. Assembly: Pair(s) assembled with 1-1/2" to 2-1/2" left-hand lay. Flame-retardant, non-wicking fillers where required to provide a round cable.

e. Cable Shield: 1.35 mil (single pair) or 2.35 mil (multiple pairs) blue double-faced aluminum/synthetic polymer backed tape overlapped to provide 100% coverage. 7-strand tinned copper drain wire (two sizes smaller than conductors for single pair, or same size as conductors for multiple pairs).

f. Jacket: Black, flame-retardant polyvinyl chloride per UL Subject 13, rip cord under jacket.

g. Compliance: UL listed as Power-Limited Tray Cable for use in Class II and III circuits in accordance with Article 725 of the National Electrical Code. Suitable for wet or dry locations with conductor operating temperatures to 105C. Pass flame test for use in cable tray, sunlight resistant,and oil resistant

2.2.7 2kV Power Cable

For [temporary] [penstock]grounding system.

a. Conductors: Uncoated stranded copper per ASTM B 8.

b. Insulation: UL listed as Type RHH or RHW-2, VW-1, NEMA WC 8 and UL 44.

c. Compliance (sizes 1/0 and larger): UL listed as Tray Cable. Suitable for wet or dry locations with conductor operating temperatures to 90C, emergency overload rating to 130C and short

circuit rating to 250C. Pass vertical tray flame test requirements of IEEE Std 383. Sunlight resistant, oil resistant and suitable for use at elevated temperatures.

2.3 SURGE PROTECTIVE DEVICES

Surge protective devices poles and ratings shall be appropriate for the connected system.

2.3.1 Transient Voltage Surge Suppressors (TVSS)

Transient voltage surge suppressors shall be provided as indicated. Surge suppressors shall meet the requirements of IEEE C62.41, IEEE C62.45, UL 1449, UL Category Section 37.3 (25kA test) and be UL listed and labeled. Features shall include internal 200 kA rated fusing, indicator lights for UL protection (green) and fault condition (red) for each phase, 80 kA peak surge current rating per phase.

2.3.2 Secondary Surge Arresters

Secondary surge arresters shall be provided as indicated. Arresters shall meet the requirements of IEEE C62.11 and NFPA 70 Article 280, and shall be UL listed as Secondary Surge Arresters. Arresters which fail in the faulted mode shall be internally or externally protected by 2000 kA rated fuses.

2.4 CONDUIT AND TUBING

2.4.1 Electrical, Zinc-Coated Steel Metallic Tubing (EMT)

UL 797

2.4.2 Electrical Nonmetallic Tubing (ENT)

NEMA TC 13.

2.4.3 Electrical Plastic Tubing and Conduit

NEMA TC 2.

2.4.4 Flexible Steel Conduit

General-purpose type, UL 1. Liquid tight, UL 360 and UL 1660.

2.4.5 Intermediate Metal Conduit

UL 1242.

2.4.6 PVC Coated Rigid Steel Conduit

NEMA RN 1.

2.4.7 Rigid Aluminum Conduit

ANSI C80.5 and UL 6.

2.4.8 Galvanized Rigid Steel Conduit

UL 6.

2.4.9 Rigid Plastic

NEMA TC 2, UL 651 and UL 651A.

2.4.10 Surface Metal Electrical Raceways and Fittings

UL 5.

2.9 CONDUIT AND DEVICE BOXES AND FITTINGS

2.9.1 Device Boxes

For rigid metal conduit, weatherproof, galvanized malleable iron. NEMA ICS 6, Type 4 gasketed. NEMA OS 1 and UL 514C.

2.5.2 Boxes, Nonmetallic, Outlet and Flush-Device Boxes and Covers

NEMA OS 2 and UL 514C.

2.5.3 Boxes, Outlet for Use in Hazardous (Classified) Locations

UL 886.

2.5.4 Boxes, Switch (Enclosed), Surface-Mounted

UL 98.

2.5.5 Fittings for Conduit and Outlet Boxes

UL 514B.

2.5.6 Deflection Fittings

For rigid metal conduit, weatherproof, bronze end couplings, neoprene sleeve, stainless steel bands, for 3/4" movement and 30 degree deflection, with tinned copper braid bonding jumper.

2.5.7 Expansion Fittings

For rigid metal conduit, weatherproof, galvanized malleable iron, for 4" minimum movement, with tinned copper braid bonding jumper.

2.9.6 Fittings For Use in Hazardous (Classified) Locations

UL 886.

2.9.7 Fittings, PVC, for Use with Rigid PVC Conduit and Tubing

UL 514B.

2.6 CONDUIT PLASTIC COATING

NEMA RN 1, Type A-40.

2.7 CONNECTORS, WIRE PRESSURE

2.7.1 For Copper Conductors

UL 486A and UL 486B.

2.8 ELECTRICAL GROUNDING AND BONDING EQUIPMENT

UL 467.

2.8.1 Ground Rods

Ground rods shall be of [copper-clad steel conforming to UL 467] [zinc-coated steel conforming to ANSI C135.30] [solid stainless steel] not less than [15.9] [19.1] mm [5/8] [3/4] inch in diameter by[2.4] [3.1] meter [8] [10] feet in length of the sectional type driven full length into the earth.

2.8.2 Grounding Conductors

Grounding conductors shall be bare, except where installed with associated phase conductors they shall be of the same insulation as the phase conductors and green color-coded. Insulated grounding conductors need not be rated more than 600 volts. Bare conductors shall be ASTM B 8 soft-drawn, unless otherwise indicated. Aluminum shall not be used.

2.8.3 Grounding and Bonding Connections

Grounding and bonding connections, conforming to IEEE Std 837, shall be made with copper compression connectors or exothermic welds. They shall be installed following the manufacturers' instructions.

2.9 ENCLOSURES

NEMA ICS 6 [or NEMA 250] [or UL 698 for use in hazardous (classified) locations,] unless otherwise specified.

2.9.1 Cabinets and Boxes

Cabinets and boxes with volume greater than 0.0164 cubic meters 100 cubic inches shall be in accordance with UL 50, hot-dip, zinc-coated, if sheet steel.

2.9.2 Circuit Breaker Enclosures

UL 489.

2.9.3 Circuit Breaker Enclosures for Use in Hazardous (Classified) Locations

UL 877.

2.10 FIXTURES, LIGHTING AND FIXTURE ACCESSORIES/COMPONENTS

Fixtures shown on contract drawings (if any) and UL 844 for fixtures to be installed in hazardous (classified) locations. Fixtures, accessories and components, including ballasts, lampholders, lamps, starters and starter holders, shall conform to industry standards specified below.

2.10.1 Fixture "[_]"

a. Fixture: 100 Watt high pressure sodium small flood, 6 x 5 beam spread. Rectangular die-cast aluminum housing, heat and impact resistant tempered glass lens, die-cut reflector, closed-cell silicone door gasket, tray-mounted ballast, medium-base porcelan socket, maximum weight (with ballast), 25 pounds. Housing color grey. Listed for wet locations, UL 1572 UL 1572.

b. Ballasts: Ballasts: High reactance, high power factor, -40 degree F, 120 Volt, fused. UL 1029.

c. Mounting: Adjustable angle, knuckle or slipfitter mount for 1-1/4" pipe.

2.10.2 Fixture "[_]"

a. Fixture: 250 Watt high pressure sodium small flood, 7 x 6 beam spread. Rectangular die-cast aluminum housing, heat and impact resistant tempered glass lens, die-cut reflector, closed-cell silicone door gasket, tray-mounted ballast, medium-base porcelan socket, maximum weight (with ballast), 55 pounds. With a NEMA twistlock receptacle-mounted NEMA type photocontrol. Housing color grey. Adjustable angle slipfitter mount. Listed for wet locations, UL 1572.

b. Ballasts: High reactance, high power factor, -40 degree F, 120 Volt, fused. UL 1029.

c. Pole: 30' tall,.hinged, tapered, 55,000 PSI steel. ASTM Grade steel base plate with ASTM A 366 base cover. Shot blasted, primed and painted grey, or galvanized. Tennon top to match fixture. Handhole with ground stud at base. Complete with anchor bolts, nuts, flat and lock washers, nut covers, and all mounting hardware. With lowering/raising device: winch, arm,rotating steel drum with 2-way ratchet lock, stranded aircraft cable, and all required accessories, providing for easy hand- or electric drill-operated lowering and lifting of the pole.

2.10.3 Fixture, Auxiliary or Emergency

UL 924.

2.10.4 Fluorescent

a. Fixture: UL 1570. Fixtures shall be plainly marked for proper lamp and ballast type to identify lamp diameter, wattage, color and start type. Marking shall be readily visible to service personnel, but not visible from normal viewing angles.

b. Ballasts: [Magnetic ballast, energy-saving, high power factor, Class P, automatic-resetting Type, approved for the application by the Certified Ballast Manufacturers: ANSI C82.1 and UL 935. Two-lamp ballasts shall be used for each pair of lamps within a fixture or within continuous mounted fixtures. Single-lamp ballasts shall be used for individually mounted single-lamp fixtures and where an odd single-lamp fixture occurs at the end of a continuous group.][Electronic Ballast. Electronic ballasts shall consist of a rectifier, high frequency inverter, and power

control and regulation circuitry. The ballasts shall be UL listed, Class P, with a Class A sound rating and shall contain no PCBs. Ballasts shall meet 47 CFR 18 for electromagnetic interference and shall not interfere with the operation of other electrical equipment. Design shall withstand line transients per IEEE C62.41, Category A. Unless otherwise indicated, the minimum number of ballasts shall be used to serve each individual fixture, using one, two, three or four lamp ballasts. A single ballast may be used to serve multiple fixtures if they are continuous mounted, factory manufactured for that installation with an integral wireway, and are identically controlled.]

(a) Light output regulation shall be +/- 10%.

(b) Voltage input regulation shall be +/- 10%.

(c) Lamp current crest factor shall be no more than 1.6.

(d) Ballast factor shall be not less than 85% nor more than 100%, unless otherwise indicated.

(e) A 60 Hz filter shall be provided. Flicker shall be no more than 10% with any lamp suitable for the ballast.

(f) Ballast case temperature shall not exceed 25 degree Celsius rise above 40 degree Celsius ambient, when tested in accordance with UL 935.

(g) Total harmonic distortion shall be in the range of 10-20%.

(h) Power factor shall not be less than 0.95.

(i) Ballasts shall operate at a frequency of 20 kHz or more.

(j) Operating filament voltage shall be 2.5 to 4.5 volts.

(k) Warranty. Three year full warranty including a $10 labor allowance.

(l) Lampholders, Starters, and Starter Holders: UL 542.

2.10.5 High-Intensity-Discharge

a. Fixture: UL 1572.

b. Ballasts: UL 1029.

2.11 INSTRUMENTS AND CONTROLS

2.11.1 Pilot Lights

Compact pilot lights, NEMA ICS 6, Type 4 (watertight) and Type 13 (oiltight), push-to-test, light-emitting diode lamp, 120 VAC, plastic color cap (color as indicted), UL File E42259.

2.11.2 Rotary Control Switch

Non-illuminated three-position selector switch with spring return both sides to center, two contact blocks for open-off-close operation, NEMA ICS 6,

Type 4 (watertight) and Type 13 (oiltight), red-colored gloved hand knob, 6 Ampere make/break at 120 VAC.

2.11.3 Digital Indicator

For 4-20mA two-wire loop, 3.5/4.5 digit display, selectable decimal point position, wide-ranging zero and span adjustabile display, "%" label, 1.65 x 3.60 cutout size, 120 VAC. Action Instruments V509 (less power supply) to match existing.

2.12 MOTORS, AC

Motors; NEMA MG 1, UL 1004. For energy management selection; NEMA MG 10. For hazardous (classified) locations; UL 674.

2.12.1 Rating

Thekilowatt horsepower rating of motors should be limited to no more than 125 percent of the maximum load being served unless a NEMA standard size does not fall within this range, in which case the next larger NEMA standard motor size shall be used.

2.12.2 Motor Efficiencies

Motors shall be [standard efficiency][high efficiency] type, unless otherwise indicated, with the minimum full-load efficiencies indicated in the following table. Motors provided as an integral part of motor driven equipment are excluded from this requirement if a minimum seasonal or overall efficiency requirement is indicated for that equipment by the provisions of another section.

Minimum Motor Efficiencies

kW	Std. Efficiency	High Efficiency
0.746	77.0	85.5
1.12	78.5	85.5
1.49	78.5	85.5
2.24	78.5	88.5
3.73	82.5	88.5
5.60	84.0	90.0
7.46	85.5	90.0
11.2	85.5	91.0
14.9	87.5	92.0
18.7	88.5	92.0
22.4	88.5	92.0
29.8	88.5	92.0
37.3	89.0	92.5
44.8	89.0	92.5
56.9	89.0	95.5
74.6	90.0	93.5
93.3	91.0	94.5
112	91.0	94.5
149	91.0	94.5
187	91.0	94.5
224	91.0	94.5
261	91.0	94.5
298	91.0	94.5

Minimum Motor Efficiencies

kW	Std. Efficiency	High Efficiency
373	91.0	94.5

Minimum Motor Efficiencies

HP	Std. Efficiency	High Efficiency
1	77.0	85.5
1.5	78.5	85.5
2	78.5	85.5
3	78.5	88.5
5	82.5	88.5
7.5	84.0	90.0
10	85.5	90.0
15	85.5	91.0
20	87.5	92.0
25	88.5	92.0
30	88.5	92.0
40	88.5	92.0
50	89.0	92.5
60	89.0	92.5
75	89.0	95.5
100	90.0	93.5
125	91.0	94.5
150	91.0	94.5
200	91.0	94.5
250	91.0	94.5
300	91.0	94.5
350	91.0	94.5
400	91.0	94.5
500	91.0	94.5

2.12.3 Valve Operator Motors

Squirrel cage induction motor for 3-phase, 60 Hz, 460 Volt supply. 15 Minute duty cycle, dynamic torque nominal 20% of starting torque, Class F insulation, with two Class B thermal contacts embedded within the motor windings for thermal overload protection.

2.13 MOTOR CONTROLS

2.13.1 Magnetic Motor Starters

NEMA ICS 1, NEMA ICS 2, NEMA ICS 3 and NEMA ICS 6, and UL 508 and UL 845. Starters shall be [NEMA][IEC] sized for the indicated motors and shall have control power transformers adequately sized for the indicated control circuits and connected devices.

2.13.1.1 Combination Starters

Combination starters shall be provided with [circuit breakers] [fusible switches] [switches equipped with high-interrupting-capacity current-limiting fuses].

2.13.1.2 Reduced-Voltage Starters

Reduced-voltage starters shall be provided [for polyphase motors [_____] kW ([_____] hp) [_____] hp or larger][as indicated]. Reduced-voltage starters shall be of the single-step autotransformer, reactor, or resistor type having an adjustable time interval between application of reduced and full voltages to the motors. Wye-delta reduced voltage starter or part winding increment starter having an adjustable time delay between application of voltage to first and second winding of motor may be used in lieu of the reduced voltage starters specified above for starting of motor-generator sets, centrifugally operated equipment or reciprocating compressors provided with automatic unloaders.

2.13.2 Manual Starters

Single or double pole tumbler switches specifically designed for alternating-current operation shall be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating.

2.13.3 Starter Enclosures

NEMA ICS 6, Type [1][3R][4, 4X and 5][3R and Type 12, with breather]. Where indicated, combination starters shall be marked as "Suitable for use as service equipment" per NFPA 70 Section 230-66 and UL 869A.

2.13.4 Overload Protection

Each motor shall be provided with overload protection. Polyphase motors shall have overload protection in each ungrounded conductor. The overload-protection device may be provided either integral with the motor or controller, or mounted in a separate enclosure. Unless otherwise specified, the protective device shall be of the manually reset type.

2.13.5 Solid State Overload Relays

Solid state overload relays shall have 3-to-1 trip current adjustment; phase loss and unbalance protection and light-emitting-diode power indications. Relays shall be ambient temperature insensitive and shall be [self-powered] [separately powered]. Additional features shall include: [switch selectable trip class,] [Class II ground fault detection,] [Form C relay output,] [analog output module,] [electrical remote reset].

2.13.6 Low-Voltage Motor Overload Relays

[Thermal] [and] [magnetic current] overload relays shall conform to NEMA ICS 2 and UL 508. Overload protection shall be provided either integral with the motor or motor controller, and shall be rated in accordance with the requirements of NFPA 70. [Standard units shall be used for motor starting times up to 7 seconds.] [Slow units shall be used for motor starting times from 8 to 12 seconds.] [Quick trip units shall be used on hermetically sealed, submersible pumps, and similar motors.]

2.13.7 Construction

Manual reset type thermal relays shall be [melting alloy] [bimetallic] construction. Automatic reset type thermal relays shall be bimetallic construction. Magnetic current relays shall consist of a contact mechanism and a dash pot mounted on a common frame.

2.13.8 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Trip current ratings shall be established by selection of the overload device. Where the controller is remotely-located or difficult to reach, an automatic reset, non-compensated overload relay shall be provided. Manual reset overload relays shall be provided otherwise, and at all locations where automatic starting is provided. Where the motor is located in a constant ambient temperature, and the thermal device is located in an ambient temperature that regularly varies by more than minus 10 degrees C, 18 degrees F, an ambient temperature-compensated overload relay shall be provided.

2.13.9 Automatic Control Devices

2.13.9.1 Direct Control

Automatic control devices (such as thermostats, float or pressure switches) which control the starting and stopping of motors directly shall be designed for that purpose and have an adequate kilowattcurrent or horsepower rating.

2.13.9.2 Pilot-Relay Control

Where the automatic-control device does not have a sufficient rating for direct control, a magnetic starter shall be used, with the automatic-control device actuating the pilot-control circuit.

2.13.9.3 Manual/Automatic Selection

a. Where combination manual and automatic control is specified and the automatic-control device operates the motor directly, a double-throw, three-position tumbler or rotary switch (marked MANUAL-OFF-AUTOMATIC) shall be provided for the manual control.

b. Where combination manual and automatic control is specified and the automatic-control device actuates the pilot control circuit of a magnetic starter, the magnetic starter shall be provided with a three-position selector switch marked MANUAL-OFF-AUTOMATIC.

c. Connections to the selector switch shall be such that; only the normal automatic regulatory control devices will be bypassed when the switch is in the Manual position; all safety control devices, such as low-or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch. Control circuit connections to any MANUAL-OFF-AUTOMATIC switch or to more than one automatic regulatory control device shall be made in accordance with wiring diagram approved by the Contracting Officer unless such diagram is included on the drawings. All controls shall be 120 volts or less unless otherwise indicated.

2.13.10 Motor Control Centers

Control centers shall conform to the requirements of NEMA ICS 1, NEMA ICS 2, NEMA ICS 3 and NEMA ICS 6, and UL 508 and UL 845. Control centers shall be indoor type and shall contain combination starters and other equipment as

indicated. Control centers shall be NEMA ICS 2, Class [_____], Type [_____]. Each control center shall be mounted on floor sills or mounting channels. Each circuit shall have a suitable metal or laminated plastic nameplate with white cut letters. Motor control centers shall be provided with a full-length ground bus bar.

2.14 CONTROL DEVICES

2.14.1 Non-Illuminated Push-Button Switches

Momentary contact push button switches, heavy duty, non-illuminated, NEMA ICS 6 Type 4 (watertight) and Type 13 (oiltight). Contact blocks, 600-Volt, 10-Amp make, break, and continuous at 75% power factor per UL 508. Operator and blocks as indicated.

2.14.2 Rotary Control Switches

Non-illuminated three-position selector switch with spring return both sides to center, two contact blocks for open-off-close operation, NEMA ICS 6, Type 4 (watertight) and Type 13 (oiltight), red-colored gloved hand knob. Contact blocks, 600-Volt, 10-Amp make, break, and continuous at 75% power factor per UL 508. Operator and blocks as indicated.

2.14.3 Float Switches

Single-pole double-throw, 8-Amp 250-Volt mechanical switch in an eccentrically weighted hermetically sealed, pear-shaped polypropylene plastic casing, with 3-wire heavy-duty PVC plastic jacketed cable. Operating point on rising level shall be 30 degrees from vertical. Operating poin on decending level shall be 10 degrees from vertical. Maximum angular displacement when fully immersed shall be 60 degrees from vertical; switch shall not float in water. The cable shall extend unspliced from the float to the control termination.

2.15 INDICATING DEVICES

Text

1.15.1 Pilot Lights

Compact pilot lights, NEMA ICS 6 Type 4 (watertight) and Type 13 (oiltight), push-to-test, light-emitting diode lamp, 120 VAC, plastic color cap (color as indicted), UL File E42259.

2.15.2 Digital Indicators

For 4-20mA two-wire loop, 3.5/4.5 digit display, selectable decimal point position, wide-ranging zero and span adjustabile display, "%" label, 1.65 x 3.60 cutout size, 120 VAC. Action Instruments V509 (less power supply) to match existing.

2.16 PANELBOARDS

NEMA ICS 1, NEMA ICS 2, NEMA ICS 3 and NEMA ICS 6, and UL 508 and UL 845. Panelboards supplying non-linear loads shall have neutrals sized for 200 percent of rated current.

2.16.1 480 Volt Branch Circuit Panelboards

Rated for 3-phase 3-wire 480 Volt service, 14 kA (symmetrical) fully rated short circuit interrupting capacity, NEMA PB 1, UL 50 and UL 67.. 100 Ampere main circuit breaker, 24 pole copper main buses, copper ground bar, and UL 1449 and UL 1283 transient voltage surge suppressor. Dead-front construction, seismically qualified, in a NEMA ICS 6 Type 4X and 12 enclosure with breather.

2.16.2 Circuit Breakers

480 Volt, 14 kA (symmetrical) interrupting capacity, bolt-in type, single or multi-pole, heavy duty, quick-make, quick-break circuit breakers conforming to NEMA AB 1 and UL 489. Automatic, thermal-magnetic tripping devices in each pole, providing inverse time delay and instantaneous circuit protection, with all poles opening simultaneously. Common handle, overcenter toggle-type mechanism, trip-free to prevent contacts being held closed against a short-circuit or sustained overload. Handle shall assume a position between "ON" and "OFF" when automatically tripped. Clearly visible ampacity ratings. Suitable for mounting and operating in any position. Lugs listed for copper conductors only, UL 486E. Ampacities as indicated

2.17 RECEPTACLES

2.17.1 Hospital Grade

UL 498.

2.17.2 Heavy Duty Grade

NEMA WD 1. Devices shall conform to all requirements for heavy duty receptacles.

2.17.3 Standard Grade

UL 498.

2.17.4 Ground Fault Interrupters

UL 943, Class A or B.

2.17.5 Hazardous (Classified) Locations

UL 1010.

2.17.6 NEMA Standard Receptacle Configurations

NEMA WD 6.

#.1 Single and Duplex, 15-Ampere and 20-Ampere, 125 Volt

15-ampere non-locking: NEMA type 5-15R; locking: NEMA type L5-15R.
20-ampere non-locking: NEMA type 5-20R; locking: NEMA type L5-20R.

2.18 Service Entrance Equipment

UL 869A.

2.19 SAFETY SWITCHES

Visible blade, heavy duty, with quick-make and quick-break operating mechanism. Three-pole,not fusible, 600 Volt; UL 98.[Heavy duty, gasketed, cast metal enclosure with drilled and tapped conduit entry.] NEMA ICS 6, Type [1] [3R] [4, 4X and 5].[3R and Type 12, with breather].

2.20 SPLICE, CONDUCTOR

UL 486C.

2.21 POWER-SWITCHGEAR ASSEMBLIES INCLUDING SWITCHBOARDS

Assemblies shall be metal-enclosed, freestanding general-purpose [type] [ventilated type] in accordance with NEMA PB 2, UL 891, and IEEE ANSI/IEEE C37.20.1 and shall be installed to provide front and rear access. Busses shall be [copper] [aluminum]. Assembly shall be approximately 2.3 meters 90 inches high; arrangement of circuit breakers and other items specified shall be as indicated. The withstand rating and interrupting capacity of the [switchgear] [switchboards] and [circuit breakers] [fuses] shall be based on the maximum fault current available.

2.21.1 Circuit Breakers

Circuit breakers shall be [stationary] [drawout] [medium-voltage power circuit breakers] [low-voltage power circuit breakers] [molded-case circuit breakers] [molded-case circuit breakers coordinated with current-limiting fuses] [insulated-case, systems type circuit breakers] [4-position drawout type circuit breaker compartments with cell switches for connected, test; disconnected and withdrawn positions].

2.21.2 Auxiliary Equipment

2.21.2.1 Instruments

Instruments shall be long scale, 173 mm 6.8 inches minimum, semiflush rectangular, indicating or digital switchboard type, mounted at eye level.

a. Ammeter, range 0 to [_____] amperes, complete with selector switch having off position and positions to read each phase current.

b. Voltmeter, range 0 to [_____] volts, complete with selector switch having off position and positions to read each phase [to phase] [to neutral] voltage.

2.21.2.2 Control Switch

A control switch with indicating lights shall be provided for each electrically operated breaker.

2.21.2.3 Control Power Sources

Control buses and control power transformers shall conform to the requirements of Section 16311 MAIN ELECTRIC SUPPLY STATION AND SUBSTATION, where required. Control power shall be [125-volt DC] [48-volt DC] [120-volt AC] [_____].

2.22 SNAP SWITCHES

Screw terminals. With weatherproof, gasketed, cast covers, UL 20.

2.23 TAPES AND TIES

2.23.1 Plastic Tape

UL 510.

2.23.2 Rubber Tape

UL 510.

2.23.3 Wire/Cable Ties

UL 94. Nylon, self-locking, self extinguishing, 85 degree C rated.

2.24 TRANSFORMERS

Single- and three-phase transformers shall have two windings per phase. Full-capacity standard NEMA taps shall be provided in the primary windings of transformers unless otherwise indicated. Three-phase transformers shall be configured with [delta-wye] [wye-delta] windings, except as indicated. "T" connections may be used for transformers rated 15 kVA or below. Transformers supplying non-linear loads shall be UL listed as suitable for supplying such loads with a total K-factor not to exceed K-[9] [13] [_____] and have neutrals sized for 200 percent of rated current.

2.24.1 Transformers, Dry-Type

Transformers shall have 220 degrees C insulation system for transformers 15 kVA and greater, and shall have 180 degrees C insulation system for transformers rated 10 kVA and less, with temperature rise not exceeding [150] [115] [80] degrees C under full-rated load in maximum ambient temperature of 40 degrees C. [Transformer of 150 degrees C temperature rise shall be capable of carrying continuously 100 percent of nameplate kVA without exceeding insulation rating.] [Transformer of 115 degrees C temperature rise shall be capable of carrying continuously 115 percent of nameplate kVA without exceeding insulation rating.] [Transformer of 80 degrees C temperature rise shall be capable of carrying continuously 130 percent of nameplate kVA without exceeding insulation rating.]

2.24.1.1 600 Volt or Less Primary

NEMA ST 20, UL 506, general purpose, dry-type, self-cooled, [ventilated] [unventilated] [sealed] [epoxy-resin cast coil,]. Transformers shall be provided in NEMA [1] [3R] [_____] enclosure. Transformers shall be quiet type with maximum sound level at least 3 decibels less than NEMA standard level for transformer ratings indicated.

2.24.1.2 601 to 34,500 Volt Primary

[Distribution: Ventilated, [epoxy-resin cast coil,] 1 to 500 kVA, single phase, and 15 to 500 kVA, three-phase, low-voltage 120-600 volts: ANSI C57.12.50.] [Power: Ventilated, [epoxy-resin cast coil,] 501 kVA and larger, three-phase, low-voltage 208Y/120 to 4160 volts: ANSI C57.12.51.] [Power: Sealed, [epoxy-resin cast coil,] 501 kVA and larger, three-phase, low-voltage 208Y/120 to 4160 volts: ANSI C57.12.52.]

2.24.2 Liquid-Insulated Transformers

IEEE ANSI/IEEE C57.12.00, ANSI C57.12.10, ANSI C57.12.13, ANSI C57.12.27, ANSI C57.12.70, IEEE ANSI/IEEE C57.12.80, IEEE ANSI/IEEE C57.12.90, IEEE ANSI/IEEE C57.98, and IEEE ANSI/IEEE C57.100. Transformers [shall] [may] may be [mineral-oil] [or] [silicone] [or] [high-molecular weight hydrocarbon (HMWH)] insulated type. Voltage and KVA ratings shall be as indicated. Pressure relief valves and relays required for safe operation in an interior location or vault shall be provided. [Single kVA ratings shown are based on self-cooled operation.] [Dual kVA ratings require that transformers be equipped for forced air cooling. Forced air cooling shall include the fans and controls necessary to operate the fans when the self-cooling temperature rating is attained.] [Transformers rated above 300 kVA shall be equipped with features to permit the future addition of cooling fans, controls, and wiring.] Temperature rise shall not exceed [55/65] [_____] degrees C under full load operation in an ambient temperature of 40 degrees C. Percent voltage impedance shall be [_____] [manufacturer's standard] [as required to limit the available fault current to less than the withstand rating of the equipment fed by the transformer]. The basic impulse insulation level (BIL) rating shall be not less than [95] [110] [125] [_____] kV for the distribution voltage shown. Nameplates shall be provided in accordance with IEEE ANSI/IEEE C57.12.00.

2.24.3 Average Sound Level

The average sound level in decibels (dB) of transformers shall not exceed the following dB level at 300 mm 12 inches for the applicable kVA rating range listed unless otherwise indicated:

kVA Range	dB Sound Level
1-50	50
51-150	55
151-300	58
301-500	60
501-700	62
701-1000	64
1001-1500	65
1501 & above	70

2.25 ISOLATED POWER SYSTEM EQUIPMENT

UL 1047, with monitor UL 1022.

2.26 WATTHOUR METERS, UTILITY REVENUE

Watthour meters shall conform to ANSI C12.1 and ANSI C12.10, except numbered terminal wiring sequence and case size may be the manufacturer's standard. Watthour meters shall be of the [drawout switchboard type] [socket-mounted [outdoor] [indoor] type] having a 15-minute, cumulative form, demand register meeting ANSI C12.4 and provided with not less than two and one-half stators. Watthour demand meters shall have factory-installed electronic pulse initiators meeting the requirements of ANSI C12.1. Pulse initiators shall be solid-state devices incorporating light-emitting diodes, phototransistors, and power transistors, except that mercury-wetted output contacts are acceptable. Initiators shall be totally contained within watthour demand meter enclosures, shall be capable of operating up to speeds of 500 pulses per minute with no false pulses, and

shall require no field adjustments. Initiators shall be calibrated for a pulse rate output of one pulse per 1/4 disc revolution of the associated meter and shall be compatible with the indicated equipment.

2.27 WATTHOUR/DEMAND METERS, CHECK

ANSI C12.10 for self-contained [watthour] [watthour-demand] meter with pulse-initiators for remote monitoring of watt-hour usage [and instantaneous demand]. [Meter shall be drawout switchboard type.] [Meter shall be socket-mounted [outdoor] [indoor] type.] Meter shall be Class [100] [200] [as indicated].

2.28 INSTRUMENT TRANSFORMERS

2.28.1 General

Instrument transformers shall comply with ANSI C12.11 and IEEE ANSI/IEEE C57.13. Instrument transformers shall be configured for mounting in/on the device to which they are applied. Polarity marks on instrument transformers shall be visually evident and shown on drawings.

2.28.2 Current Transformers

Unless otherwise indicated, bar, wound, or window-type transformers are acceptable; and except for window-type units installed over insulated buses, transformers shall have a BIL rating consistent with the rated BIL of the associated switchgear or electric power apparatus bushings, buses or conductors. Current transformers shall have the indicated ratios. The continuous thermal-current rating factor shall be not less than [1.0] [1.2] [1.5] [2.0] [3.0] [4.0]. Other thermal and mechanical ratings of current transformer and their primary leads shall be coordinated with the design of the circuit breaker and shall be not less than the momentary rating of the associated circuit breaker. Circuit protectors shall be provided across secondary leads of the current transformers to prevent the accidental open-circuiting of the transformers while energized. Each terminal of each current transformer shall be connected to a short-circuiting terminal block in the circuit interrupting mechanism cabinet, power transformer terminal cabinet, and in the associated instrument and relay cabinets.

2.28.2.1 Current Transformers for Power Transformers

[Single-ratio] [Multi-ratio] bushing type current transformers shall be provided internally around power transformer bushings as shown. [Single-ratio units shall have a minimum metering accuracy class of [0.6B-0.5] [0.3B-0.5].] [Multi-ratio units shall have a minimum relaying accuracy voltage class of [_____] for either a C or T classification.]

2.28.2.2 Current Transformers for Metal-Enclosed Switchgear

Single-ratio units, used for metering and relaying, shall have a metering accuracy class rating of [_____] [B._____]. Single-ratio units, used only for relaying, shall have a relaying accuracy class rating of [_____] for [either] a C [or T] classification.

2.28.2.3 Current Transformers for Metal-Clad Switchgear

Single-ratio units, used for metering and relaying, shall have a metering accuracy class rating of [_____] [B._____]. Single-ratio units, used only for relaying, shall have a relaying accuracy class rating of [_____] for

[either] a C [or T] classification.

2.28.2.4 Current Transformers for kWH and Demand Metering (Low Voltage)

Current transformers shall conform to IEEE ANSI/IEEE C57.13. Provide current transformers with a metering accuracy Class of 0.3 through [_____], with a minimum RF of [_____] at 30 degrees C, with 600-volt insulation, and 10 kV BIL. Provide butyl-molded, window-type current transformers mounted [on the transformer low-voltage bushings. Route current transformer leads in a location as remote as possible from the power transformer secondary cables to permit current measurements to be taken with hook-on-ammeters.] [in the current transformer cabinet.]

2.28.2.5 Voltage Transformers

Voltage transformers shall have indicated ratios. Units shall have an accuracy class rating of [_____]. Voltage transformers shall be of the drawout type having current-limiting fuses in both primary and secondary circuits. Mechanical interlocks shall prevent removal of fuses, unless the associated voltage transformer is in a drawout position. Voltage transformer compartments shall have hinged doors.

2.29 WIRING DEVICES

NEMA WD 1 for wiring devices, and NEMA WD 6 for dimensional requirements of wiring devices.

2.30 LIQUID DIELECTRICS

Liquid dielectrics for transformers, capacitors, and other liquid-filled electrical equipment shall be non-polychlorinated biphenyl (PCB) mineral oil or less flammable liquid as specified. Nonflammable fluids shall not be used. Tetrachloroethylene (perchloroethylene) and 1, 2, 4 trichlorobenzene fluids shall be certified by the manufacturer as having less than 2 parts per million (ppm) PCB content. In lieu of the manufacturer's certification, the Contractor may submit a test sample of the dielectric in accordance with ASTM D 4059 at a testing facility approved by the Contracting Officer. Equipment with test results indicating PCB level exceeding 2 ppm shall be replaced.

2.31 COORDINATED POWER SYSTEM PROTECTION

Analyses shall be prepared to demonstrate that the equipment and system constructed meet the specified requirements for equipment ratings, coordination, and protection. They shall include a load flow analysis, a fault current analysis, and protective device coordination study. The studies shall be performed by a registered professional engineer with demonstrated experience in power system coordination in the last three years. The Contractor shall provide a list of references complete with points of contact, addresses and telephone numbers. The selection of the engineer is subject to the approval of the Contracting Officer.

2.31.1 Scope of Analyses

The fault current analysis, and protective device coordination study shall begin at: [the source bus and extend down to system buses where fault availability is 10,000 amperes (symmetrical) for building/facility 600 volt level distribution buses] [the source bus and extended through the secondary side of transformers for medium voltage distribution feeders.]

[the source bus and extend through [outgoing breakers] [outgoing medium voltage feeders, down to the individual protective devices for medium voltage radial taps] [outgoing medium voltage feeders, through the secondary side of transformers] [as indicated] for main electric supply substations.] [the nearest upstream device in the existing source system and extend through the downstream devices at the load end.]

2.31.2 Determination of Facts

The time-current characteristics, features, and nameplate data for each existing protective device shall be determined and documented. [The Contractor shall coordinate with the [commercial power company] [_____] for fault current availability at the site.] [The Contractor shall utilize the fault current availability indicated as a basis for fault current studies.]

2.31.3 Single Line Diagram

A single line diagram shall be prepared to show the electrical system buses, devices, transformation points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device or transformation point shall have a unique identifier. If a fault-impedance diagram is provide, impedance data shall be shown. Locations of switches, breakers, and circuit interrupting devices shall be shown on the diagram together with available fault data, and the device interrupting rating.

2.31.4 Fault Current Analysis

2.31.4.1 Method

The fault current analysis shall be performed in accordance with methods described in IEEE Std 242, and IEEE Std 399.

2.31.4.2 Data

Actual data shall be utilized in fault calculations. Bus characteristics and transformer impedances shall be those proposed. Data shall be documented in the report.

2.31.4.3 Fault Current Availability

Balanced three-phase fault, bolted line-to-line fault, and line-to-ground fault current values shall be provided at each voltage transformation point and at each power distribution bus. The maximum and minimum values of fault available at each location shall be shown in tabular form on the diagram or in the report.

2.31.5 Coordination Study

The study shall demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. The study shall include a description of the coordination of the protective devices in this project. Provide a written narrative that describes: which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situation where system coordination is not achievable due to device limitations (an analysis of any device curves which order overlap); coordination between upstream and downstream devices; and relay settings. Recommendations to improve or enhance system

reliability, and detail where such changes would involve additions or modifications to the contract and cost changes (addition or reduction) shall be provided. Composite coordination plots shall be provided on log-log graph paper.

2.31.6 Study Report

a. The report shall include a narrative: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.

b. The study shall include descriptive and technical data for existing devices and new protective devices proposed. The data shall include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices.

c. The report shall document utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristic curves, current transformer ratios, and relay device curves and protective device ratings and settings.

d. The report shall contain fully coordinated composite time-current characteristic curves for each bus in the system, as required to ensure coordinated power system protection between protective devices or equipment. The report shall include recommended ratings and settings of all protective devices in tabulated form.

e. The report shall provide the calculations performed for the analyses, including computer analysis programs utilized. The name of the software package, developer, and version number shall be provided.

PART 3 EXECUTION

Equipment and devices shall be installed and energized in accordance with the manufacturer's published instructions. Excavation, trenching, and backfilling shall conform to the requirements of Section 02316 EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS. Concrete work shall have minimum 20 MPa 3000 psi compressive strength and conform to the requirements of Section [03300 CAST-IN-PLACE STRUCTURAL CONCRETE] [03307 CONCRETE FOR MINOR STRUCTURES] Concrete reinforcing shall be as specified in Section 03200 CONCRETE REINFORCEMENT.

3.1 GROUNDING

Grounding shall be in conformance with NFPA 70, the contract drawings, and the following specifications.

#.1 Grounding Grid

A grounding grid, consisting of the indicated configuration of bare copper conductors and driven ground rods shall be installed as shown on the drawings. Grounding grid shall comply with IEEE Std 80. Frames of metal-enclosed equipment, chain-link fencing, metal-structures, and other noncurrent-carrying metal items shall be connected to the ground grid as shown. Fences and handrails shall be grounded at each fixed gate post, each corner post, and at intermediate posts as indicated. Each gate section shall be bonded to its gate posts with a 1/8 inch x 1 inch 1/8 x 1

inch flexible braided copper strap and ground post clamps. Fence ground clamps shall be of a type that inhibits corrosion between metal parts.

#.1 Grid Grounding Electrode

Grid grounding electrodes shall be installed as shown consisting of bare copper conductors installed 24 inches, plus or minus 3 inches, below the finished top of soil grade. Grid conductors shall be bonded to all rod electrodes, and to all other intersecting grid conductors. Grid conductors shall be sized as shown.

#.1 Grounding Electrodes

Grounding electrodes shall be as indicated.

#.1 Driven Rod Electrodes

Unless otherwise indicated, ground rods shall be driven into the earth until the tops of the rods are approximately one foot below finished grade.

#.1 Grounding and Bonding Connections

Connections above grade may be fusion welding or with solderless compression connectors. Connections below grade shall be fusion welded. Connections above grade shall be fusion welded. Connectors shall comply with UL 467.

#.1 Grounding and Bonding Conductors

Grounding and bonding conductors include all conductors used to bond enclosures, equipment frames and structural members to the grounding grid. Grounding and bonding conductors shall be sized as shown. After being located to provide maximum physical protection, exposed grounding conductors shall be securely attached to structural supports at not more than two foot intervals with suitable fasteners. Bends greater than 45 degrees in ground conductors are not permitted. Routing of ground conductors through concrete should be avoided. When concrete penetration is necessary, nonmetallic conduit shall be cast flush with the points of concrete entrance and exit so as to provide an opening for the ground conductor, and the opening shall be sealed with a suitable compound after installation.

3.1.1 Ground Resistance

The resistance to ground shall be measured using the fall-of-potential method described in IEEE Std 81. The maximum resistance of a grounding electrode shall not exceed 25 ohms under normally dry conditions. If this resistance cannot be obtained, additional grounding rods not less than 1.8 meters 6 feet on centers. If sectional type rods are used, additional sections may be coupled and driven with the first rod. In high-ground-resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, the Contracting Officer shall be notified immediately.

3.1.2 Ground Bus

Ground bus shall be provided in the electrical equipment rooms as indicated. Noncurrent-carrying metal parts of [transformer neutrals and

other electrical] [electrical] equipment shall be effectively grounded by bonding to the ground bus. The ground bus shall be bonded to both the entrance ground, and to a ground rod or rods as specified above having the upper ends terminating approximately 100 mm 4 inches above the floor. Connections and splices shall be of the brazed, welded, bolted, or pressure-connector type, except that pressure connectors or bolted connections shall be used for connections to removable equipment. For raised floor equipment rooms in computer and data processing centers, a minimum of 4, one at each corner, multiple grounding systems shall be furnished. Connections shall be bolted type in lieu of thermoweld, so they can be changed as required by additions and/or alterations.

3.1.7 Equipment Grounding

A green equipment grounding conductor, sized in accordance with NFPA 70 shall be provided, regardless of the type of cable or conduit. Equipment grounding bars shall be provided in all panelboards. The equipment grounding conductor shall be carried back to the service entrance grounding connection or separately derived grounding connection. All equipment grounding conductors, including metallic raceway systems used as such, shall be bonded or joined together in each wiring box or equipment enclosure. Metallic raceways and grounding conductors shall be checked to assure that they are wired or bonded into a common junction. Metallic boxes and enclosures shall also be bonded to these grounding conductors by an approved means per NFPA 70. When boxes for receptacles, switches, or other utilization devices are installed, any designated grounding terminal on these devices shall also be bonded to the equipment grounding conductor junction with a short jumper.

3.2 WIRING METHODS

Wiring shall conform to NFPA 70, the contract drawings, and the following specifications. Except as otherwise indicated, wiring shall consist of insulated cables and conductors installed in [rigid aluminum conduit] [and] [galvanized rigid steel conduit] [and] [rigid plastic conduit] [and] [electrical metallic tubing] [and] [electrical nonmetallic tubing] [and] [intermediate metal conduit] [and] [PVC coated galvanized rigid steel conduit]. Where cables and wires are installed in cable trays it shall, where possible, be lifted into place on the tray rather than pulled onto the tray. Where pulling is necessary, suitable rollers, designed for the purpose, shall be used.[Nonmetallic-sheathed cables or metallic-armored cables may be installed in areas permitted by NFPA 70.] Wire fill in conduits shall be based on NFPA 70 for the type of conduit and wire insulations specified.[Wire fill in conduits located in Class I or II hazardous areas shall be limited to 25 percent of the cross sectional area of the conduit.]

3.2.1 Conduit and Tubing Systems

Conduit and tubing systems shall be installed as indicated. Conduit sizes shown are based on use of copper conductors with insulation types as described in paragraph WIRING METHODS. Minimum size of raceways shall be 15 mm. 1/2 inch. Only metal conduits will be permitted when conduits are required for shielding or other special purposes indicated, or when required by conformance to NFPA 70. Nonmetallic conduit and tubing may be used in damp, wet or corrosive locations when permitted by NFPA 70 and the conduit or tubing system is provided with appropriate boxes, covers, clamps, screws or other appropriate type of fittings. Electrical metallic tubing (EMT) may be installed only within buildings. EMT may be installed

in concrete and grout in dry locations. EMT installed in concrete or grout shall be provided with concrete tight fittings. EMT shall not be installed in damp or wet locations, or the air space of exterior masonry cavity walls. Bushings, manufactured fittings or boxes providing equivalent means of protection shall be installed on the ends of all conduits and shall be of the insulating type, where required by NFPA 70. Only UL listed adapters shall be used to connect EMT to rigid metal conduit, cast boxes, and conduit bodies. Aluminum conduit may be used only where installed exposed in dry locations. Nonaluminum sleeves shall be used where aluminum conduit passes through concrete floors and firewalls. Penetrations of above grade floor slabs, time-rated partitions and fire walls shall be firestopped in accordance with Section 07270 FIRESTOPPING. Except as otherwise specified, IMC may be used as an option for rigid steel conduit in areas as permitted by NFPA 70. Raceways shall not be installed under the firepits of boilers and furnaces and shall be kept 150 mm 6 inches away from parallel runs of flues, steam pipes and hot-water pipes. Raceways shall be concealed within finished walls, ceilings, and floors unless otherwise shown. Raceways crossing structural expansion joints or seismic joints shall be provided with suitable expansion fittings or other suitable means to compensate for[the building] expansion and contraction and to provide for continuity of grounding. Wiring installed in [underfloor duct system] [underfloor raceway system] shall be suitable for installation in wet locations.

3.2.1.1 Pull Wires

A pull wire shall be inserted in each empty raceway in which wiring is to be installed if the raceway is more than 15 meters 50 feet in length and contains more than the equivalent of two 90-degree bends, or where the raceway is more than 45 meters 150 feet in length. The pull wire shall be of No. 14 AWG zinc-coated steel, or of plastic having not less than 1.4 MPa (200 psi) 200 pounds per square inch tensile strength. Not less than 254 mm 10 inches of slack shall be left at each end of the pull wire.

3.2.1.2 Conduit Stub-Ups

Where conduits are to be stubbed up through concrete, a short elbow shall be installed below grade to transition from the horizontal run of conduit to a vertical run. A conduit coupling fitting, threaded on the inside shall be installed, to allow terminating the conduit flush with the finished floor. Wiring shall be extended in rigid threaded conduit to equipment, except that where required, flexible conduit shall be used 150 mm 6 inches above the floor. Empty or spare conduit stub-ups shall be plugged flush with the finished floor with a threaded, recessed plug.

3.2.1.3 Through or Below Slab-on-Grade, or in the Ground

Electrical wiring below through slab-on-grade shall be protected by a conduit system. Rigid steel or IMC conduits passing vertically through slabs-on-grade, installed below slab-on-grade, or in the earth shall be field wrapped with 0.254 mm 0.010 inch thick pipe-wrapping plastic tape applied with a 50 percent overlay, or shall have a factory-applied polyvinyl chloride, plastic resin, or epoxy coating system.

3.2.1.4 Installing in Concrete, including Slabs on Grade

Conduit installed in concrete, including slabs-on-grade shall be rigid steel or IMC. Conduits shall be installed as close to the middle of concrete slabs as practicable, without disturbing the reinforcement. Conduits shall be no less than 1 1/2 inches below finished concrete

surfaces. Outside diameter shall not exceed 1/3 of the slab thickness and conduits shall be spaced not closer than 3 diameters on centers except at cabinet locations where the slab thickness shall be increased as approved by the Contracting Officer. Where conduit is run near reinforcing steel, the conduit shall be spaced a minimum of one conduit diameter away but not less than 25.4 mm one inch from the reinforcing steel.

3.2.1.5 Changes in Direction of Runs

Changes in direction of runs shall be made with symmetrical bends or cast-metal fittings. Field-made bends and offsets shall be made with an approved hickey or conduit-bending machine. Crushed or deformed raceways shall not be installed. Trapped raceways in damp and wet locations shall be avoided where possible. Lodgment of plaster, dirt, or trash in raceways, boxes, fittings and equipment shall be prevented during the course of construction. Clogged raceways shall be cleared of obstructions or shall be replaced.

3.2.1.6 Supports

Metallic conduits and tubing,and the support system to which they are attached, shall be securely and rigidly fastened in place to prevent vertical and horizontal movement at intervals of not more than 3 meters 10 feet and within 900 mm 3 feet of boxes, cabinets, and fittings, with approved galvanized malleable iron one-hole clamps and clamp backs[,.pipe straps][, wall brackets][, conduit clamps][, conduit hangers][, threaded C-clamps][, beam clamps][, ceiling trapeze].[Loads and supports shall be coordinated with supporting structure to prevent damage or deformation to the structure. Loads shall not be applied to joist bridging.] Attachment shall be [by wood screws or screw-type nails to wood;][by toggle bolts on hollow masonry units;][by expansion bolts on concrete or brick;][by machine screws, or welded threaded studs on steel work;][heat-treated or spring-steel-tension clamps on steel work].[Nail-type nylon anchors or threaded studs driven in by a powder charge and provided with lock washers and nuts may be used in lieu of expansion bolts or machine screws. Raceways or pipe straps shall not be welded to steel structures. Cutting the main reinforcing bars in reinforced concrete beams or joists shall be avoided when drilling holes for support anchors. Holes drilled for support anchors, but not used, shall be filled. In partitions of light steel construction, sheet-metal screws may be used. Raceways shall not be supported using wire or nylon ties. Raceways shall be independently supported from the structure. Upper raceways shall not be used as a means of support for lower raceways. Supporting means shall not be shared between electrical raceways and mechanical piping or ducts. Cables and raceways shall not be supported by ceiling grids. Except where permitted by NFPA 70, wiring shall not be supported by ceiling support systems. [Conduits shall be fastened to [weatherproof or cast]boxes and cabinets by threaded conduit hubs.][Conduits shall be fastened to sheet-metal] boxes and cabinets by two locknuts where required by NFPA 70, where insulating bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, a single locknut and bushing may be used. Threadless fittings for electrical metallic tubing shall be of a type approved for the conditions encountered. Additional support for horizontal runs is not required when EMT rests on steel stud cutouts.

3.2.1.7 Exposed Raceways

Exposed raceways shall be installed parallel or perpendicular to walls, structural members, or intersections of horizontal and vertical planes.

[Raceways under raised floors and above accessible ceilings shall be considered as exposed installations in accordance with NFPA 70 definitions.]

#.1 Expansion and Deflection

Long, straight, exterior conduit runs shall have provision for expansion by using expansion fittings, center or end anchoring, and oversized clamps. Deflection fittings shall be installed where conduits cross expansion joints or transition from embedded or buried to surface mounted.

3.2.1.9 Exposed Lengths of Conduit, Over 600 Volts

Exposed lengths of conduit containing power conductors operating at more than 600 volts shall have two red bands 50 mm 2 inches wide spaced 200 mm 8 inches apart painted near each coupling; the intervening space between the red bands shall be painted white, and on the white space the voltage shall be stenciled in black: [_____] volts.

3.2.1.10 Communications Raceways

Communications raceways indicated shall be installed in accordance with the previous requirements for conduit and tubing and with the additional requirement that no length of run shall exceed 15 meters 50 feet for 15 mm 1/2 inch and 20 mm 3/4 inch sizes, and 30 meters 100 feet for 25 mm 1 inch or larger sizes, and shall not contain more than two 90-degree bends or the equivalent. Additional pull or junction boxes shall be installed to comply with these limitations whether or not indicated. Inside radii of bends in conduits of 25 mm (1 inch) 1 inch size or larger shall not be less than ten times the nominal diameter.

3.2.2 Busway Systems

Busway systems shall be of the voltage, capacity, and phase characteristics indicated. Vertical runs of busways within 1.8 meters 6 feet of the floor shall have solid enclosures. Busways shall be supported at intervals not exceeding 1.5 meters, 5 feet, and shall be braced properly to prevent lateral movement. Busways penetrating walls or floors shall be provided with flanges to completely close wall or floor openings.

3.2.3 Cable Trays

Cable trays shall be supported in accordance with the recommendations of the manufacturer but at no more than 1.8 meter 6 foot intervals. Contact surfaces of aluminum connections shall be coated with an antioxidant compound prior to assembly. Adjacent cable tray sections shall be bonded together by connector plates of an identical type as the cable tray sections. The Contractor shall submit the manufacturer's certification that the cable tray system meets all requirements of Article 318 of NFPA 70. The cable tray shall be installed and grounded in accordance with the provisions of Article 318 of NFPA 70. Data submitted by the Contractor shall demonstrate that the completed cable tray systems will comply with the specified requirements. Cable trays shall terminate 250 mm 10 inches from both sides of smoke and fire partitions. Conductors run through smoke and fire partitions shall be installed in 103 mm (4 inch) 4 inch rigid steel conduits with grounding bushings, extending 300 mm 12 inches beyond each side of the partitions. The installation shall be sealed to preserve the smoke and fire rating of the partitions. Penetrations shall be firestopped in accordance with Section 07270 FIRESTOPPING.

#.1 Direct-Burial

Cables shall be buried directly in the earth as indicated. Minimum cover from the top of a cable to finished grade shall be [_____] mm, 36 inches.

#.1 Trenching

Trenches for direct-burial cables shall be excavated to depths required to provide the minimum necessary cable cover. Bottoms of trenches shall be smooth and free of stones and sharp objects. Where bottoms of trenches comprise materials other than sand, a 75 mm 3 inch layer of sand shall be laid first and compacted to approximate densities of surrounding firm soil.

#.1 Cable Burial

Cables shall be unreeled along the sides of or in trenches and carefully placed on sand or earth bottoms. Pulling cables into direct-burial trenches from a fixed reel position will not be permitted, except as required to pull cables through conduits under paving or railroad tracks. Where cables cross, a separation of at least 75 mm 3 inches shall be provided, unless each cable circuit is protected by a nonmetallic conduit sleeve at the crossing. Where single-conductor cable is installed, all 3 phases and the neutral shall be installed in the same sleeve. Bend radius of any cable shall be not less than 12 times the diameter of the cable. In no case shall cables be left under longitudinal tension. The first 150 mm 6 inch layer of backfill shall be of sand. Machine compaction shall not be used within 150 mm 6 inches of the cable.

#.1 Other Requirements

Where direct-burial cables cross under roads or other paving exceeding 1.5 m 5 feet in width, such cables shall be installed in concrete-encased ducts. Where direct-burial cables cross under railroad tracks, such cables shall be installed in reinforced concrete-encased ducts. Ducts shall extend at least 300 mm 1 foot beyond each edge of any paving and at least 1.5 m 5 feet beyond each side of any railroad tracks. Cables may be pulled into duct from a fixed reel where suitable rollers are provided in the trench. Where direct burial cable transitions to duct-enclosed cable, direct-burial cables shall be centered in duct entrances, and a waterproof nonhardening mastic compound shall be used to facilitate such centering. If paving or railroad tracks are in place where cables are to be installed, coated rigid steel conduits driven under the paving or railroad tracks may be used in lieu of concrete-encased ducts. Damage to conduit coatings shall be prevented by providing ferrous pipe jackets or by predrilling. Where cuts are made in any paving, the paving and subbase shall be restored to their original condition.

3.2.5 Cables and Conductors

Installation shall conform to the requirements of NFPA 70.[Covered, bare or insulated conductors of circuits rated over 600 volts shall not occupy the same equipment wiring enclosure, cable, or raceway with conductors of circuits rated 600 volts or less.]

3.2.5.1 Sizing

Unless otherwise noted, all sizes are based on copper conductors and the insulation types indicated. Sizes shall be not less than indicated. Branch-circuit conductors shall be not smaller than No. 12 AWG. Conductors

for branch circuits of 120 volts more than 30 meters 100 feet long and of 277 volts more than 70 meters 230 feet long, from panel to load center, shall be no smaller than No. 10 AWG. Class 1 remote control and signal circuit conductors shall be not less than No. 14 AWG. Class 2 remote control and signal circuit conductors shall be not less than No. 16 AWG. Class 3 low-energy, remote-control and signal circuits shall be not less than No. 22 AWG.

3.2.5.2 Aluminum Conductors

Aluminum conductors shall not be used.

#.1 Cable Systems

Cable systems shall be installed where indicated. Cables shall be installed concealed behind ceiling or wall finish where practicable. Cables shall be threaded through holes bored on the approximate centerline of wood members; notching of surfaces will not be permitted. Sleeves shall be provided through bond beams of masonry-block walls for threading cables through hollow spaces. Exposed cables shall be installed parallel or at right angles to walls or structural members. In rooms or areas not provided with ceiling or wall finish, cables and outlets shall be installed so that a room finish may be applied in the future without disturbing the cables or resetting the boxes. Exposed nonmetallic-sheathed cables less than 1.2 meters 4 feet above floors shall be protected from mechanical injury by installation in conduit or tubing.

3.2.5.3 Cable Joints, Terminations and Connectors

Splices and terminations shall be made in an accessible location. Crimping tools and dies shall be approved by the connector manufacturer for use with the type of connector and conductor.

a. Copper Conductors, 600 Volt and Under: Cable splices and terminations shall be rated at not less than 600 Volts. Splices in conductors No. 10 AWG and smaller shall be made with an insulated, solderless, pressure type connector, conforming to the applicable requirements of UL 486A. Splices in conductors No. 8 AWG and larger shall be made with noninsulated, solderless, pressure type connector, conforming to the applicable requirements of UL 486A and UL 486B. Splices shall then be covered with an insulation and jacket material equivalent to the conductor insulation and jacket. Splices below grade or in wet locations shall be sealed or waterproofed by a sealant-filled, thick wall, heat shrinkable, thermosetting tubing or by pouring a thermosetting resin into a mold that surrounds the joined conductors.

c. Greater Than 600 Volt: Cable splices shall be made in accordance with the cable manufacturer's recommendations and Section 16375 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

3.2.4.6 Conductor Identification and Tagging

Power, control, and signal circuit conductor identification shall be provided within each enclosure where a tap, splice, or termination is made. Where several feeders pass through a common pull box, the feeders shall be tagged to indicate clearly the electrical characteristics, circuit number, and panel designation. Phase conductors of low voltage power circuits

shall be identified by color coding. Phase identification by a particular color shall be maintained continuously for the length of a circuit, including junctions.

a. Color coding shall be provided for service, feeder, branch, and ground conductors. Color shall be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in the same raceway or box, other neutral shall be white with colored (not green) stripe. The color coding for 3-phase and single-phase low voltage systems shall be as follows:

   120/208-volt, 3-phase: Black(A), red(B), and blue(C).
   277/480-volt, 3-phase: Brown(A), orange(B), and yellow(C).
   120/240-volt, 1-phase: Black and red.

b. Conductor phase and voltage identification shall be made by color-coded insulation for all conductors smaller than No. 6 AWG. For conductors No. 6 AWG and larger, identification shall be made by color-coded insulation, or conductors with black insulation may be furnished and identified by the use of half-lapped bands of colored electrical tape wrapped around the insulation for a minimum of 75 mm 3 inches of length near the end, or other method as submitted by the Contractor and approved by the Contracting Officer.

c. Control and signal circuit conductor identification shall be made by color-coded insulated conductors, plastic-coated self-sticking printed markers, permanently attached stamped metal foil markers, or equivalent means as approved. Control circuit terminals of equipment shall be properly identified. Terminal and conductor identification shall match that shown on approved detail drawings. Hand lettering or marking is not acceptable.

3.3 BOXES AND SUPPORTS

Boxes shall be provided in the wiring or raceway systems where required by NFPA 70 for pulling of wires, making connections, and mounting of devices or fixtures. Pull boxes shall be furnished with screw-fastened covers. Indicated elevations are approximate, except where minimum mounting heights for hazardous areas are required by NFPA 70. Unless otherwise indicated, boxes for wall switches shall be mounted 1.2 meters 48 inches above finished floors or grade. Switch and outlet boxes located on opposite sides of fire rated walls shall be separated by a minimum horizontal distance of 600 mm. 24 inches. The total combined area of all box openings in fire rated walls shall not exceed 0.0645 square meters 100 square inches per 9.3 square meters. 100 square feet. Maximum box areas for individual boxes in fire rated walls vary with the manufacturer and shall not exceed the maximum specified for that box in UL Elec Const Dir. Only boxes listed in UL Elec Const Dir shall be used in fire rated walls.

3.3.1 Box Applications

Each box shall have not less than the volume required by NFPA 70 for number of conductors enclosed in box. Boxes for metallic raceways[, 102 by 102 mm 4 by 4 inch nominal size and smaller,] shall be of the cast-metal hub type[when located in normally wet locations, when flush and surface mounted on outside of exterior surfaces, or when located in hazardous areas]. Cast-metal boxes [installed in wet locations and boxes installed flush with

the outside of exterior surfaces]shall be gasketed.[Boxes for mounting lighting fixtures shall be not less than 102 mm 4 inches square, or octagonal, except smaller boxes may be installed as required by fixture configuration, as approved.] Cast-metal boxes with 2.4 mm 3/32 inch wall thickness are acceptable. Large size boxes shall be NEMA [1] [2] [3R] [4] [_____] [7] [12] or as shown. Boxes in other locations shall be sheet steel except that aluminum boxes may be used with aluminum conduit, and nonmetallic boxes may be used with nonmetallic conduit and tubing or nonmetallic sheathed cable system, when permitted by NFPA 70. Boxes for use in masonry-block or tile walls shall be square-cornered, tile-type, or standard boxes having square-cornered, tile-type covers.

3.3.2 Brackets and Fasteners

Boxes and supports shall be fastened[to wood with wood screws or screw-type nails of equal holding strength,][with bolts and metal expansion shields on concrete or brick,][with toggle bolts on hollow masonry units,][and with machine screw or welded studs on steel work]. [Threaded studs driven in by powder charge and provided with lockwashers and nuts, or nail-type nylon anchors may be used in lieu of expansion shields, or machine screws.]Penetration of more than 38.1 mm (1-1/2 inches) 1-1/2 inches into reinforced-concrete beams or more than 19.1 mm (3/4 inch) 3/4 inch into reinforced-concrete joists shall avoid cutting any main reinforcing steel. The use of brackets which depend on gypsum wallboard or plasterboard for primary support will not be permitted. In partitions of light steel construction, bar hangers with 25 mm 1 inch long studs, mounted between metal wall studs or metal box mounting brackets shall be used to secure boxes to the building structure. When metal box mounting brackets are used, additional box support shall be provided on the side of the box opposite the brackets. This additional box support shall consist of a minimum 300 mm 12 inch long section of wall stud, bracketed to the opposite side of the box and secured by two screws through the wallboard on each side of the stud. Metal screws may be used in lieu of the metal box mounting brackets.

3.3.3 Mounting in Walls, Ceilings, or Recessed Locations

In walls or ceilings of concrete, tile, or other non-combustible material, boxes shall be installed so that the edge of the box is not recessed more than 6 mm 1/4 inch from the finished surface. Boxes mounted in combustible walls or ceiling material shall be mounted flush with the finished surface. The use of gypsum or plasterboard as a means of supporting boxes will not be permitted. Boxes installed for concealed wiring shall be provided with suitable extension rings or plaster covers, as required. The bottom of boxes installed in masonry-block walls for concealed wiring shall be mounted flush with the top of a block to minimize cutting of the blocks, and boxes shall be located horizontally to avoid cutting webs of block. Separate boxes shall be provided for flush or recessed fixtures when required by the fixture terminal operating temperature, and fixtures shall be readily removable for access to the boxes unless ceiling access panels are provided.

3.3.4 Installation in Overhead Spaces

In open overhead spaces, cast-metal boxes threaded to raceways need not be separately supported except where used for fixture support; cast-metal boxes having threadless connectors and sheet metal boxes shall be supported directly from the building structure or by bar hangers. Hangers shall not be fastened to or supported from joist bridging. Where bar hangers are

used, the bar shall be attached to raceways on opposite sides of the box and the raceway shall be supported with an approved type fastener not more than 600 mm 24 inches from the box.

3.4 DEVICE PLATES

One-piece type device plates shall be provided for all outlets and fittings. Plates on unfinished walls and on fittings shall be of zinc-coated sheet steel, or cast-metal. Plates installed in wet locations shall be gasketed and provided with a hinged, gasketed cover, unless otherwise specified.

3.5 RECEPTACLES

3.5.1 Single and Duplex, 15 or 20-ampere, 125 volt

Single and duplex receptacles shall be rated [15] [20] amperes, 125 volts, two-pole, three-wire, grounding type with polarized parallel slots. Bodies shall be of [ivory] [as indicated] [_____] to match color of switch handles in the same room or to harmonize with the color of the respective wall, and supported by mounting strap having plaster ears. Contact arrangement shall be such that contact is made on two sides of an inserted blade. Receptacle shall be side- or back-wired with two screws per terminal. The third grounding pole shall be connected to the metal mounting yoke. Switched receptacles shall be the same as other receptacles specified except that the ungrounded pole of each suitable receptacle shall be provided with a separate terminal. Only the top receptacle of a duplex receptacle shall be wired for switching application. Receptacles with ground fault circuit interrupters shall have the current rating as indicated, and shall be UL Class A type unless otherwise shown. Ground fault circuit protection shall be provided as required by NFPA 70 and as indicated on the drawings.

3.5.4 Weatherproof Applications

Weatherproof receptacles shall be suitable for the environment, damp or wet as applicable, and the housings shall be labeled to identify the allowable use. Receptacles shall be marked in accordance with UL 514A for the type of use indicated; "Damp locations", "Wet Locations", "Wet Location Only When Cover Closed". Assemblies shall be installed in accordance with the manufacturer's recommendations.

3.5.4.1 Damp Locations

Receptacles in damp locations shall be mounted in an outlet box with a gasketed, weatherproof, cast-metal cover plate (device plate, box cover) and a gasketed cap (hood, receptacle cover) over each receptacle opening. The cap shall be either a screw-on type permanently attached to the cover plate by a short length of bead chain or shall be a flap type attached to the cover with a spring loaded hinge.

3.5.4.2 Wet Locations

Receptacles in wet locations shall be installed in an assembly rated for such use whether the plug is inserted or withdrawn, unless otherwise indicated. In a duplex installation, the receptacle cover shall be configured to shield the connections whether one or both receptacles are in use. [Assemblies which utilize a self-sealing boot or gasket to maintain wet location rating shall be furnished with a compatible plug at each receptacle location and a sign notifying the user that only plugs intended

for use with the sealing boot shall be connected during wet conditions].

3.5.5 Receptacles, 15-Ampere, 250-Volt

Receptacles, 15-ampere, 250-volt, shall be [single] [duplex] two-pole, three-wire, grounding type with bodies of [ivory] [as indicated] [_____] phenolic compound supported by mounting yoke having plaster ears. The third grounding pole shall be connected to the metal yoke. Each receptacle shall be provided with a mating cord-grip plug.

3.5.11 Special-Purpose or Heavy-Duty Receptacles

Special-purpose or heavy-duty receptacles shall be of the type and of ratings and number of poles indicated or required for the anticipated purpose. Contact surfaces may be either round or rectangular. One appropriate straight or angle-type plug shall be furnished with each receptacle. Locking type receptacles, rated 30 amperes or less, shall be locked by rotating the plug. Locking type receptacles, rated more than 50 amperes, shall utilize a locking ring.

3.6 SNAP SWITCHES

Snap switches shall be of the totally enclosed tumbler type. The wall switch handle and switch plate color shall be [ivory] [as indicated] [_____]. Wiring terminals shall be of the screw type or of the solderless pressure type having suitable conductor-release arrangement. Not more than [one switch] [two switches] shall be installed in a single-gang position. Switches shall be rated [15-ampere][20-ampere] [120][277]-volt for use on alternating current only. Pilot lights indicated shall consist of yoke-mounted candelabra-base sockets rated at 75 watts, 125 volts, and fitted with glass or plastic jewels. A clear 6-watt lamp shall be furnished and installed in each pilot switch. Jewels for use with switches controlling motors shall be green, and jewels for other purposes shall be red. Dimming switches shall be solid-state flush mounted, sized for the loads.

#.1 Weatherproof Applications

Switches in wet locations shall be suitable for the environment, and the housings shall be labeled to identify the allowable use.

3.7 SERVICE EQUIPMENT

Service-disconnecting means shall be of the [enclosed molded-case circuit breaker type] [fusible safety switch type] [type indicated] [type indicated in paragraph [PANELBOARDS AND LOADCENTERS] [POWER SWITCHGEAR ASSEMBLIES INCLUDING SWITCHBOARDS]] with an external handle for manual operation. When service disconnecting means is a part of an assembly, the assembly shall be listed as suitable for service entrance equipment. Enclosures shall be sheet metal with hinged cover for surface mounting unless otherwise indicated.

3.8 PANELBOARDS AND LOADCENTERS

Circuit breakers and switches used as a motor disconnecting means shall be capable of being locked in the open position. Door locks shall be keyed alike. Nameplates shall be as approved. Directories shall be typed to indicate loads served by each circuit and mounted in a holder, inside the enclosure door, behind a clear protective covering. Busses shall be

[copper] [aluminum].

3.8.1 Loadcenters

Loadcenters shall be circuit breaker equipped.

3.8.2 Panelboards

Panelboards shall be circuit breaker or fusible switch equipped as indicated on the drawings. [Fusible panelboards of the multipole type may have doors over individual circuits and trim over the wiring gutter only, provided each circuit is arranged for locking in the open and closed positions and each branch circuit has an individual identification card in a cardholder with a clear plastic covering.] [Multipole fusible switches shall be of the hinged-door type; single pole fusible switches shall be of the tumbler switch and fuse type. Switches serving as a motor disconnect means shall be of the tumbler switch and fuse type. Switches serving as motor disconnect means shall be horsepower rated in conformance with UL 98.]

3.10 UNDERGROUND SERVICE

Unless otherwise indicated, interior conduit systems shall be stubbed out 1.5 m 5 feet beyond the building wall and 600 mm 2 feet below finished grade, for interface with the exterior service lateral conduits [and exterior communications conduits]. Outside conduit ends shall be bushed when used for direct burial service lateral conductors. Outside conduit ends shall be capped or plugged until connected to exterior conduit systems. Underground service lateral conductors will be extended to building service entrance and terminated in accordance with the requirements of Section 16375 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND and NFPA 70.

3.11 AERIAL SERVICE

Services shall conform to the requirements of Section 16370 ELECTRICAL DISTRIBUTION SYSTEM, AERIAL, IEEE C2, and NFPA 70. The service drop conductors shall be continuous from the point of connection on the last pole to the service mast or structural support, connected to the service entrance conductors, and shall be routed to a weatherhead, or weatherproof conduit fitting, before entry into an enclosing conduit. A drip loop shall be formed in each service conductor below the entrance to the weatherhead or the weatherproof conduit fitting. The weatherhead or weatherproof service entrance conduit fitting shall be securely fastened to a rigid galvanized steel (RGS) conduit that shall be terminated in the [meter enclosure] [service entrance equipment] which penetrates the [exterior wall] [roof]. [Penetration of the conduit through an exterior wall shall be sealed to prevent the entrance of moisture and the escape of conditioned air.] [A roof penetration fitting shall be provided for the conduit to prevent the entrance of rain.] Service entrance conductors shall be routed in [RGS] [intermediate metal conduit (IMC)] in the exterior wall, or in the interior of the building or facility that contains the [meter enclosure] [service entrance equipment]. Aerial service drop conductors will be extended to building service entrance and terminated.

3.12 MOTORS

Each motor shall conform to the kWhp and voltage ratings indicated, and shall have a service factor and other characteristics that are essential to the proper application and performance of the motors under conditions shown

or specified. Three-phase motors for use on 3-phase 208-volt systems shall have a nameplate rating of 200 volts. Unless otherwise specified, all motors shall have open frames, and continuous-duty classification based on a 40 degree C ambient temperature reference. The Contractor shall be responsible for selecting the actual kilowatt (horsepower) horsepower ratings and other motor requirements necessary for the applications indicated. When electrically driven equipment furnished under other sections of these specifications materially differs from the design, the Contractor shall make the necessary adjustments to the wiring, disconnect devices and branch-circuit protection to accommodate the equipment actually installed.

3.13 MOTOR CONTROL

Each motor [or group of motors requiring a single control] [and not controlled from a motor-control center] shall be provided [under other sections of these specifications]with a suitable controller and devices that will perform the functions as specified for the respective motors. Each motor shall be provided with overload protection. Polyphase motors shall have overload protection in each ungrounded conductor. The overload-protection device shall be provided integral with the motor controller. Unless otherwise specified, the protective device shall be of the [manually] [automatic] reset type.[Single or double pole tumbler switches specifically designed for alternating-current operation only may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating. Automatic control devices such as thermostats, float or pressure switches shall control the starting and stopping of motors as indicated.][When combination manual and automatic control is specified and the automatic-control device operates the motor directly, a double-throw, three-position tumbler or rotary switch shall be provided for the manual control; when the automatic-control device actuates the pilot control circuit of a magnetic starter, the latter shall be provided with a three-position selector switch marked MANUAL-OFF-AUTOMATIC.][Connections to the selector switch shall be such that only the normal automatic regulatory control devices will be bypassed when the switch is in the Manual position; all safety control devices, such as low- or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch.] Control circuit connections[to any MANUAL-OFF-AUTOMATIC switch or to more than one automatic regulatory control device]shall be made in accordance with a wiring diagram approved by the Contracting Officer unless such diagram is included on the drawings. All controls shall be 120 volts or less unless otherwise indicated.

3.13.1 Reduced-Voltage Controllers

Reduced-voltage controllers shall be provided for polyphase motors [_____] [_____] kW [_____] hp or larger. Reduced-voltage starters shall be of the single-step autotransformer, reactor, or resistor type having an adjustable time interval between application of reduced and full voltages to the motors. Wye-delta reduced voltage starters or part winding increment starters having an adjustable time delay between application of voltage to first and second winding of motor may be used in lieu of the reduced voltage starters specified above for starting of motor-generator sets, centrifugally operated equipment or reciprocating compressors provided with automatic unloaders.

3.13.2 Motor Control Centers

Control centers shall be indoor type and shall contain combination starters and other equipment as indicated. Control centers shall be NEMA ICS 2, Class [_____], Type [_____]. Each control center shall be mounted on floor sills or mounting channels. Each circuit shall have a suitable metal or laminated plastic nameplate with white cut letters. Combination starters shall be provided with [circuit breakers.] [fusible switches.] [switches equipped with high-interrupting-capacity current-limiting fuses.] Motor control centers shall be provided with a full-length ground bus bar.

3.13.3 Contacts

Unless otherwise indicated, contacts in miscellaneous control devices such as float switches, pressure switches, and auxiliary relays shall have current and voltage ratings in accordance with NEMA ICS 2 for rating designation B300.

3.13.4 Safety Controls

Safety controls for boilers shall be connected to a 2-wire, 120 volt grounded circuit supplied from the associated boiler-equipment circuit. Where the boiler circuit is more than 120 volts to ground, safety controls shall be energized through a two-winding transformer having its 120 volt secondary winding grounded. Overcurrent protection shall be provided in the ungrounded secondary conductor and shall be sized for the load encountered.

3.14 MOTOR-DISCONNECT MEANS

Each motor shall be provided with a disconnecting means[when required by NFPA 70 even though not indicated].[For single-phase motors, a single or double pole toggle switch, rated only for alternating current, will be acceptable for capacities less than 30 amperes, provided the ampere rating of the switch is at least 125 percent of the motor rating.] Switches shall disconnect all ungrounded conductors.

3.15 TRANSFORMER INSTALLATION

Three-phase transformers shall be connected only in a delta-wye or wye-delta configuration as indicated [except isolation transformers having a one-to-one turns ratio]. "T" connections may be used for transformers rated at 15 kVA or below. Dry-type transformers shown located within 1.5 meters 5 feet of the exterior wall shall be provided in a weatherproof enclosure. Transformers to be located within the [building] [building and vault] may be provided in the manufacturer's standard, ventilated indoor enclosure designed for use in 40 degrees C ambient temperature, unless otherwise indicated.

3.18 EQUIPMENT CONNECTIONS

Wiring not furnished and installed under other sections of the specifications for the connection of electrical equipment as indicated on the drawings shall be furnished and installed under this section of the specifications. Connections shall comply with the applicable requirements of paragraph WIRING METHODS. Flexible conduits, 2 m6 feet or less in length, with stranded conductors and separate grounding conductors, shall be provided to all electrical equipment subject to periodic removal, vibration, or movement and for all motors. Liquid-tight flexible conduits

(LTFC) shall be used in damp or wet locations.

3.18.1 Motors and Motor Control

Motors, and motor controls shall be installed in accordance with NFPA 70, the manufacturer's recommendations, and as indicated. Wiring shall be extended to motors, motor controls, and motor control centers and terminated.

3.22 FIELD TESTING

Field testing shall be performed in the presence of the Contracting Officer. The Contractor shall notify the Contracting Officer 28 days prior to conducting tests. The Contractor shall furnish all materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform all tests and inspection recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor shall maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. All field test reports will be signed and dated by the Contractor.

3.22.1 Safety

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

3.22.2 Ground-Resistance Tests

The resistance of each grounding electrode shall be measured using the fall-of-potential method defined in IEEE Std 81. Soil resistivity in the area of the grid shall be measured concurrently with the grid measurements. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

a. Single rod electrode - 25 ohms .

3.22.4 Cable Tests

The Contractor shall be responsible for identifying all equipment and devices that could be damaged by application of the test voltage and ensuring that they have been properly disconnected prior to performing insulation resistance testing. An insulation resistance test shall be performed on all low and medium voltage cables after the cables are installed in their final configuration and prior to energization. The test voltage shall be 500 volts DC applied for one minute between each conductor and ground and between all possible combinations of conductors. The minimum value of resistance shall be:

R in megohms = (rated voltage in kV + 1) x 1000/(length of cable in feet)

Each cable failing this test shall be repaired or replaced. The repaired

cable system shall then be retested until failures have been eliminated.

3.22.4.2 Low Voltage Cable Tests

a. Continuity test.

b. Insulation resistance test.

3.22.6 Motor Tests

a. Phase rotation test to ensure proper directions.

d. Insulation resistance of each winding to ground.

f. Dielectric absorption test on motor and starter.

3.22.9 Circuit Breaker Tests

The following field tests shall be performed on circuit breakers.

3.22.9.3 Molded Case Circuit Breakers

[

a. Insulation resistance test phase-to-phase, all combinations.

b. Insulation resistance test phase-to-ground, each phase.

c. Closed breaker contact resistance test.

]

d. Manual operation of the breaker.

3.22.10 Motor Control Tests

[

a. Insulation resistance test phase-to-phase, all combinations.

b. Insulation resistance test phase-to-ground, each phase.

]

c. Manual and electrical operational tests.

3.22.11 Protective Relays

Protective relays shall be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. These tests shall include pick-up, timing, contact action, restraint, and other aspects necessary to insure proper calibration and operation. Relay settings shall be implemented in accordance with the coordination study. Relay contacts shall be manually or electrically operated to verify that the proper breakers and alarms initiate. Relaying current transformers shall be field tested in accordance with IEEE ANSI/IEEE C57.13.

3.23 OPERATING TESTS

After the installation is completed, and at such time as the Contracting Officer may direct, the Contractor shall conduct operating tests for approval. The equipment shall be demonstrated to operate in accordance with the specified requirements. An operating test report shall be submitted in accordance with paragraph FIELD TEST REPORTS.

3.24 FIELD SERVICE

3.24.1 Onsite Training

The Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of [4][_] hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests. The course instruction shall cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as all major elements of the operation and maintenance manuals. Additionally, the course instructions shall demonstrate all routine maintenance operations. A [VHS] [_____] format video tape of the training shall be submitted.

3.24.2 Installation Engineer

After delivery of the equipment and if requested by the Contracting Officer, the Contractor shall furnish one or more field engineers, regularly employed by the equipment manufacturer to supervise the installation of equipment, assist in the performance of the onsite tests, oversee initial operations, and instruct personnel as to the operational and maintenance features of the equipment.

3.25 ACCEPTANCE

Final acceptance of the facility will not be given until the Contractor has successfully completed all tests and after all defects in installation, material or operation have been corrected.

-- End of Section --